SILICON CHIP

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433MHz Remote Switch Kit

Ref: Silicon Chip Magazine January 2009

Suitable for remote control of practically anything up to a range of 200m. The receiver has momentary or toggle output and the momentary period can be adjusted. Up to five receivers can be used in the same vicinity. Short-form kit contains two PCBs and all specified components.

- Requires case and 9-12VDC power
- PCB: Tx: 85 x 63mm; Rx: 79 x 48mm

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Garbage & Recycling Reminder Kit

Ref: Silicon Chip Magazine January 2013

Easy to build kit that reminds you when to put which bin out by. Up to four bins can be individually set to weekly, fortnightly or alternate week or fortnight cycles. Kit supplied with silk-screened PCB, black enclosure (83 x 54 x 31mm), pre-programmed PIC, battery and PCB mount components.

- PCB: 75 x 47mm

KC-5518

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IR Remote Extender MKII Kit

Ref: Silicon Chip Magazine October 2006

Operate your DVD player or digital decoder using its remote control from another room. Picks up the signal from the remote control and sends it via a 2-wire cable to an infrared LED located close to the device.

- Kit supplied with case, screen printed front panel, PCB with overlay and all electronic components
- Requires 9VDC and 2-wire cable for extending the IR-Tx lead (use **WB-1702 $0.50/m**).
- PCB: 79 x 47mm

KC-5432

$26.95

Do Not Disturb Phone Timer Kit

Ref: Silicon Chip Magazine May 2013

Stop intrusive phone calls when you don't want to be disturbed. Set the timer duration to one of five settings between 15 to 120 mins and the caller will get an engaged signal until the timer times out.

- Kit supplied with silk-screened PCB, black enclosure.

KC-5521

$29.95

Mains Timer Kit for Fans & Lights

Ref: Silicon Chip Magazine August 2012

This simple circuit provides a turn-off delay for a 230VAC light or a fan, such as a bathroom fan set to run for a short period after the switch has been tuned off. The circuit consumes no stand by power when load is off. Kit supplied with PCB, case and electronic components. See website for a list of alternate capacitors for different time periods.

- PCB: 60 x 76mm

KC-5512

$39.95

Tempmaster Fridge Controller Mk II Kit

Ref: Silicon Chip Magazine February 2009

Turn an old chest freezer into an energy-efficient fridge or beer keg fridge. Or convert a standard fridge into a wine cooler. These are just two of the jobs this low-cost and easy-to-build electronic thermostat kit can do without the need to modify internal wiring! Short-form kit contains PCB, sensor and all specified components. You'll need to add your own 240VDC GPO, switched IEC socket and case.

- PCB: 68 x 67mm

KC-5476

$32.95

Modules

DC to DC Converter Modules

DC voltage converter modules that will output user selectable voltages (excluding AA-0238). These could be used to power 12VDC devices from a 6VDC motorbike battery or to run 12VDC devices from a 24VDC source such as those found in trucks.

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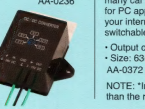

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AA-0372

NOTE: *Input voltage MUST be larger than the required output voltage.

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Automotive Kits

Headlight Reminder Kit

Ref: Silicon Chip Magazine August 2001

Features include a modulated alarm, ignition and lights monitoring, optional door switch detection, time-out alarm and a short delay before the alarm sounds. Kit includes quality solder masked PCB with overlay, case with screen printed lid and all electronic components.

- 12VDC
- PCB: 78 x 49 mm

KC-5317

$27.95

Automatic Headlights Kit for Cars

Ref: Silicon Chip Magazine October 2013

Like modern cars, this kit will turn your car headlights on automatically.

- Kit supplied with double sided, solder-masked and screen-printed PCB, diecast case, buzzer and electronic components. Cabling not included.
- 11.5-15VDC

KC-5524

$59.95

Courtesy Interior Light Delay Kit

Ref: Silicon Chip Magazine June 2004

This kit provides a time delay in your vehicle's interior light, for you to buckle-up your seat belt and get organised before the light dims and fades out. It has a 'soft' fade-out after a set time has elapsed, and has universal wiring. Kit supplied with PCB and all electronics components.

- 12-24VDC

KC-5392

$19.95

GPS Data Logger/Tracker Kit

Ref: Silicon Chip Magazine November 2013

Precisely records where your car or boat has travelled over time, which you can playback on software such as Google® Earth to map your journey. Kit supplied with silk-screened PCB, enclosure with label, pre-programmed PIC, GPS module, and electronic components. The SMD components are already pre-soldered to the PCB to save you the hassle.

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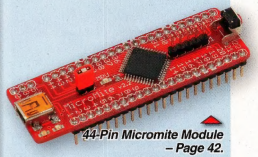

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Publisher's Letter

Electricity is a boon; electricity is a killer!

This month we have an article which highlights a hidden hazard of domestic electrical systems whereby the plumbing in a house can become lethal. How can this be? It is mainly due to corrosion and it turns out that your average plumber is more aware of the problem than most electricians. Why is that? Because if a plumber replaces a length of copper pipe in your house or needs to remove or replace your water meter, he can be exposed to the risk of electrocution.

The reason for this is that heavy electrical currents can-flow in your water pipes and through your water meter. If the water meter is removed, there may be the full 230VAC applied between the two pipe ends! If the plumber is unfortunate enough to touch the two pipe ends, he could be electrocuted. Fortunately, most plumbers are aware of this and before they even think about removing a water meter, they bridge across it with a heavy jumper lead – to provide a continuous path for the hazardous current. They should do the same thing if they need to replace a length of copper pipe elsewhere in your plumbing.

You can read about how this hazard comes about in the article, starting on page 14 but even if you don't read it, you should be aware of the basic message. In short, if you lose the Neutral connection from your home's switchboard to the power pole in your street, your water pipes could hold this lethal threat. Nor will you know anything about it unless you do some checks. All of your electrical appliances will continue to operate normally, by the way.

Perhaps you may be thinking that because you have RCDs (Residual Current Devices or safety switches) installed in your switchboard that everything is 'hunky dory'. Well, the RCDs may well protect you and your loved ones if one of your appliances develops an electrical fault but they will not give any protection against the hazard of electrical currents flowing in your water pipes.

"Oh, well", you might be thinking, "provided no-one disturbs the water pipes, nothing further can happen". Well that could be a tragic conclusion because the loss of the Neutral connection can also ultimately lead to all the pipes in your household becoming "live" and lethal. You could be electrocuted next time you take a shower. Think that is far-fetched? There have been several cases of this happening in the last few years. Ignorance is not bliss!

Indeed, the impetus for this article came about because of a letter from one of our regular correspondents whereby some of his close relatives living in a rental premises complained to the landlord about getting 'tingles' in the shower. The landlord regarded it as trivial and passed it off, saying that the previous tenants had lived with it for six years. But our reader knew better and advised his relatives to complain to their electrical retailer. And just as well that they did – they had lost the Neutral connection at the power pole and were living with the substantial risk of electrocution.

Now I am not advocating that people should be tampering with their electrical systems in any way. But people should know about our MEN (Mains Earth Neutral) system and how it can develop a hazardous condition. Furthermore, I believe that people who know about this are fundamentally safer than the vast majority of the population who are completely ignorant about the workings of electricity. If you ever hear about anyone getting 'tingles' from their water taps, make sure that they advise their electricity retailer immediately. They will get an immediate response and the problem will be fixed.

Leo Simpson

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Interference caused by NBN Fixed Wireless installations

Recently, I had an NBN Fixed Wireless installation undertaken at my home at Deep Bay which is one hour south of Hobart. The installation consists of the outdoor antenna/transceiver (ODU) and the NBN Connection Box which is located inside the house. The two units are connected by RJ45 data cable, in my case approximately five metres in length.

I immediately noticed interference to all AM radio services, taking the form of a loud "crackle " of approximately two seconds duration, every 30 seconds. I notified my service provider, iiNet, who logged it as a fault and arranged for NBN to rectify the problem.

NBN attended and removed the v2 ODU and installed a v1 ODU. This eliminated the interference. Prior to NBN rectifying the fault I had emailed the ABC reception advice service who phoned me back and advised me to contact ACMA.

I emailed ACMA who confirmed receipt of my complaint and the successful resolution of the interference. This interference does not appear to be limited to me. There are on-line discussion forums concerning the problem. The NBN technician informally confirmed that the problem is widespread and that reversion to the v1 ODU was a known cure.

I am concerned that the NBN is installing v2 ODUs in the tens of thousands, which they know causes interference to AM radio services. There is also the potential to impact on amateur radio HF frequencies.

Chris Holliday, VK7JU,
Deep Bay, Tas.

Ethernet over power works well

I read the article in the June 2014 issue on the Edimax HP-5101K Ethernet over power lines system. I thought that is just what I needed since for some reason the Ethernet cable from my office to my workshop, 30m away, went down. I suspected a mouse as the culprit and thought that rather than get under the house and run a new cable, this was for me.

I ordered it from Jaycar, plugged it in and got instant connection. It actually downloads from the Web quicker than the WiFi connection inside my house. In the Mailbag page of the July issue the question was raised as to whether it would work on different phases. The answer is no.

My brother thought he would try it from his house to his workshop, but it would not work. He suspected that the circuit breakers were limiting the signal so he eliminated a very old Clipsal circuit breaker from the circuit and it worked; not sure why, maybe burnt contacts.

So for anyone who wants to use this system, I am very impressed.

Peter Lowe,
Maclean, NSW.

Electric cars still have some way to go

Nissan built and ran an electric car in the Le Mans 24-hour race recently. The good news was that did a lap time of four minutes 22 seconds. The bad

Ethernet over power (EOP) only works on single phase

I have been employed in the telecommunications/IT industry for over 40 years and have had my fair share of new phone system installation challenges. A couple of years ago, one customer remotely located out west needed a phone system for his office staff and workshop but did not have any phone infrastructure wiring to accommodate it. After much deliberation, we planned to install an IP system connected to their normal PSTN lines and with IP extension phones connected via EOP adaptors of a well-known reputable brand.

All went fine on site until installing the last phone in a workshop in which we could not get connectivity via IP to the main system. Swapping phones and reprogramming the system gave no success. Then the penny dropped. Being an industrial site, the main power box had all three phases split off to their associated power points. Of course, the workshop power point happened to be on a separate phase to the phase for all the offices.

Calling in a local sparky confirmed this and he rewired this particular point back to the same phase as the office. This solved the problem and connectivity for the system was fixed.

In the EOP adaptor instructions it is specified that they must be installed at power points on the same phase only. I can understand this as even though the 3-phase transformer was located next to the building, with transformer losses, etc, you couldn't expect reliable transfer of high-frequency modulated signals.

Many years ago, power companies were looking at supplying broadband internet via their power lines. A local employee told me that they were going to compete against Telstra's proposed ADSL rollout. They discovered that every phase had to have its own modem located at each power transformer output as data transfer across phases was unreliable and lossy.

Warwick Talbot,
Toowoomba, Qld.

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Mailbag: continued

Argo drones had no part in search for MH370

I have received my July 2014 issue of SILICON CHIP with the Argo article. Was it an Argo drone that someone, maybe the CSIRO, modified and dropped from an aircraft to detect the Malaysian Airlines MH370 aeroplane pinging? Also is it the Argo System satellites that detect the bushwalker emergency alarm system that sells for around $400 dollars?

Roderick Wall,
Dandenong, Vic.

Dr David Maddison replies:

No modified Argo floats were used to detect the pinging of the missing aircraft's flight data recorder or cockpit voice recorder. The pings (which are now thought to have been spurious) were detected by a purpose-built device owned by the US Navy called the Towed Pinger Locator 25, see http://www.navy.mil/navydata/fact_display.asp?cid=4300&tid=400&ct=4 *which was borrowed from the US Navy and towed by the Royal Australian Navy's "Ocean Shield" vessel.*

Argos System satellites do not detect distress signals from PLBs (Personal Locator Beacons, typically used by bushwalkers and for other land-based use), ELTs (Emergency Locator Transmitter, typically used on aircraft) and EPIRBs (Emergency Position-Indicating Radio Beacons, typically used at sea). These beacons operate at a frequency of 406MHz and signals from such devices are detected by a combination of both geostationary satellites and low-earth orbiting polar satellites.

These satellites are purpose-built for environmental monitoring however they have a self-contained instrument package attached to them known as SARSAT (Search And Rescue Satellite Aided Tracking). This package receives signals and retransmits the data from such signals whereupon it is brought to the attention of Search and Rescue (SAR) authorities.

This satellite-based SAR system is known as the International Cospar-Sarsat Programme and was founded in 1979 by the USA, Canada, France and the former Soviet Union. It is now supported by around 26 countries, including Australia.

The geostationary satellites can detect distress signals immediately within their field of view but cannot provide location data if the beacon does not transmit GPS coordinates. The low-earth orbiting satellites can provide Doppler location if the beacon does not transmit position data however it may take some time before the satellite is within view of the beacon.

The detection of a signal by the geostationary satellites is still useful for SAR authorities without position data as the signal will identify the distress beacon. Personal contacts registered against that beacon ID and other data may then be able to tell authorities of the likely approximate location of the distressed person prior to position confirmation by the low-earth orbiting satellites.

Note that old-style distress beacons operating at 121.5MHz have not been monitored since 1st February 2009 and should not be used. If you purchase a beacon, it is suggested that it be GPS-enabled.

news was that it was about a minute slower than the other cars and it could only do a single lap at even that much lower speed before it ran out of battery power.

Gordon Drennan,
Burton, SA.

Comment: Nissan's ZEROD (Zero Emission On Demand) is a hybrid electric racing car with a 1.5-litre 3-cylinder engine that produces 290kW, two electric motors, lithium ion battery packs and regenerative breaking. Apparently, it can be manually switched to operate in either mode.

At Le Mans, the car managed to reach a speed above 300km/h and complete a lap using electric power only, which was a record for an electric car. It subsequently retired after about

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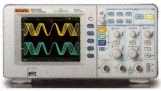

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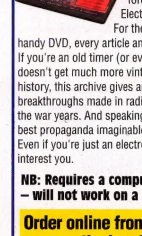

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Mailbag: continued

Power station tours are no longer available

I have just been planning a short trip which involves going past the Hazelwood Power Station in Victoria's Latrobe Valley and was disappointed to discover that tours of the power station are no longer available as they once were. This power station is responsible for producing over 5% of Australia's total energy requirements and it is a shame that interested parties cannot inspect this important piece of infrastructure (although there are viewing areas to see it from afar).

Liability for accidents was cited as one of the reasons tours were stopped. As with the cessation of tours of most of the Snowy Mountains Scheme facilities which I mentioned in a previous letter to the Editor, it is a sad reflection of our society and laws which make such inspections so difficult as well as, perhaps, the attitudes of infrastructure owners who see tours as unimportant.

Dr David Madison,
Toora, Vic.

five laps, apparently due to gearbox failure.

The cars in the same 24-hour race which finished first, second, third and fifth, were all hybrids, made by Audi, Toyota and Porsche.

RCA VoltOhmyst article & circuit loading

The article on the RCA VoltOhmyst in the June 2014 issue was very interesting and informative. I especially liked the photographs. One of my long term projects is on RF diode probes. Is there a picture of the internals of this one?

Regarding the AVO meter and its 'loading' or 'burden' on the circuit being measured causing inaccurate readings, many of the manuals published in England during the heyday of the AVO would state the the voltages given were measured with either an AVO or a 20kΩ/V multimeter; so the technician wouldn't have to calculate the drop in voltage caused by the meter.

Unlike electronic meters, the total load was dependent on the range used. In the AVO8 Mk.2, the DC ranges were 2.5V, 10V, 25V, 100V, 250V, 500V, 1kV & 2.5kV. The top three ranges gave loadings of 10MΩ, 20MΩ & 50MΩ, respectively, equal to or greater than many electronic/digital meters.

The AVO8s had a "REV MC" button which was a double-pole reversing switch connected to the meter movement. This did have to be held down to use that function, although in the later versions (model 9?) that became a press on/press off switch. I should note that I am a fan of the model 8 AVO. I still have the one I bought while a trainee with the GPO in London in the mid 1960s; it cost me about £30 (five weeks' wages in those days).

An observation on auto-ranging meters: some models

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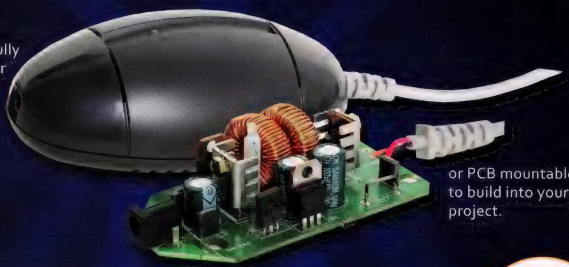

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Mailbag: continued

Volcanoes not major emitters of carbon dioxide

The letter from John MacDonald in the Mailbag pages of the June 2014 issue, published with no attempt to verify his 'facts', does SILICON CHIP magazine a great disservice. The idea, that volcanic activity releases more CO_2 into the atmosphere than human activity has been doing the rounds for many years and is typical of this sort of disinformation based on a truth (volcanoes do emit CO_2) followed up by an easily demonstrated falsehood.

It relies on a lazy reader who accepts (the obvious) first truth and then the follow-on false statement is more likely to be taken as truth. Those predisposed to conspiracy theories will agree with the first truth and stoke their paranoia with "And why haven't we been told about this! Obviously, it's a cover up." The case in point regarding volcanoes has been shown to be false, by a factor of ≈100!

Check the following reference and follow the other references if you are in doubt: **http://volcanoes.usgs.gov/hazards/gas/climate.php**

Please consider and lend greater weight to accredited, reviewed sources of information. The kicker in this case is that the most significant climatic impact of volcanic eruptions is fine sulphate aerosols that lead to a net cooling due to reflection of sunlight. So a big eruption, as alluded to in the June 2014 issue, should actually lead to a cooling effect!

The next problem with the letter is the anecdotal evidence that summer is arriving later because the sea temperature is cooler, proven by an inability to now swim in the sea (when older) than some years ago (when younger). The first problem is it is a single point measurement and assumes the world will uniformly heat up. This is not the case – the weather, ocean currents etc are a complex system.

Secondly, young bodies tend to be more tolerant and cope well with cold conditions than older bodies. Not knowing the relevant ages of the author and how far back he is recollecting, I can not say if this is the case for him. My anecdotal evidence is that 40-50 years ago I commonly saw icicles hanging off fences in winter but I have not seen these for many years!

Kelvin Jones,
Kingston, Tas.

Comment: It is true that personal recollections may not be accurate or any indication of global climate trends. But neither can the citing of specific weather events (tornadoes, bushfires, heat-waves etc) by climate activists be justified to promote the fear of global warming.

are unable to measure the resistance of high-value inductors, eg, the primary windings of toroidal mains transformers. The "back EMF" resulting from connecting the meter results in a low initial current (= high resistance). Then as the current rises, the meter changes down a range, causing a step in the current to the inductor and an increase in the back-EMF. The meter just keeps changing ranges and doesn't give a stable reading.

Rodger Bean,
Watson, ACT.

Right of reply

In response to Bob Lile's letter in the Mailbag pages of the July 2014 issue, I agree with many of his statements but a lack of understanding on my part is not one. Any time-dependent data set is only valid to the last time of its recording and even predicting something to an hour later is extrapolation. The laws of physics and mathematics underpin everything in our physical world and they are invariant but that does not mean their usage is correct.

I agree that boundary conditions are important. I worked for almost 11 years as the technician assigned to supervise a university civil engineering hydraulics (fluids) laboratory and I have seen the effects of tiny changes of physical models in which the laws of physics are for real. When the same

Mortar locating radar story solved a mystery

My son sent me the article on the mortar locating radar in Vietnam (Serviceman's Log, February 2014) and boy-oh-boy did it solve a 40-year old mystery! On those nights when mortar bombs were fired at us by the enemy in Nui Dat, always as we tried to sleep at night unless on sentry duty, we hoped the locating detachment would feed the mortar base-plate co-ordinates to our gun battery for counter fire.

Alas, we listened intently for the bang of our counter fire but it never came and now we know why! G. C. of Briar Hill, bless him, solved the problem after my departure in September 1968 so please pass my grateful thanks to him.

It is nice to know that at last that VC mortar crew got their just desserts! For me, it was a fascinating article.

Peter Murray,
(547 Signal Troop Vietnam 1968)
Canberra, ACT.

modelling is performed using computer simulation, the laws of physics must be implemented in algorithms and the accuracy of implementation is paramount.

If tiny effects are smoothed in the simulation by taking larger element sizes, the inaccuracy per calculation may be very small. Repeat the process many times and the final inaccuracy can be substantial.

I looked at the GFDL web page that Bob Lile quoted and it is obvious that the scientists have expended an enormous amount of work on their climate modelling and as good scientists do, they make their programs and data sets available. They also describe what they have done and the factors that they take into account. It is very impressive. However, the program and data files are huge.

This makes it very hard to check that there are no mistakes that could skew the results. Also, are the models correct in the first place? The researchers must make assumptions. It is literally impossible to resolve to the level of detail at which nature operates. If they were to try, we would all be long dead when the programs finished running.

I looked at the graphs generated by their CM3 model in which the worst scenario results in a temperature rise of 5°C by the year 2100 and the least by 2°C. Average earth temperature rises of these amounts require very large amounts of constant power input to maintain the temperatures.

Applying the Stefan-Boltzmann law suggests power values of the order of millions of gigawatts. In other words, we would need to burn fossil fuels and generate nuclear or fusion power at many times the current rate for the worst scenario.

This could occur with substantial population increase and particularly if everyone in the world achieves the same standard of living as the developed world. But that would be the result of consumption and not the result of an assumed climate change. However, regardless of the opinions of everyone in this debate concerning climate change and warming, eventually the question becomes, "Do you trust the scientists?".

In response to Tim Herne's letter, I suggest the following ideas. Without the climate debate, I do believe the world will have shortages of cheap energy and protein. I cannot suggest a solution to this but I do have a couple of pet ideas that could help. Firstly, it is a terrible shame to see the energy of bushfires wasted. Why don't we harvest this fuel load?

Surely, some experimental work could be done to assess its viability because I can see three benefits. It would supplement our energy supply at base load. It would reduce the fire hazard, and it would provide jobs. Secondly, why don't we try to emulate the algal blooms of the North Atlantic Ocean. We have large oceans surrounding this nation with areas devoid of sufficient nutrients.

Again, why don't we conduct trials providing the nutrients and see if we can produce the large fish stocks of the North Atlantic. Surely, it is worth a try. The main benefits are food production and carbon dioxide absorption besides employment.

George Ramsay, B.App.Sc (Physics),
Holland Park, Qld.

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Mailbag: continued

CO_2 exceeds 400ppm threshold

With reference to the Publisher's Letter in the April 2014 issue, the sky fell on Hawaii in June, all because carbon dioxide levels peeped above the much-hyped 400 ppm hurdle. Chicken Littles all over the world squawked into their friendly media megaphones about numerous imminent global warming disasters. One warned: "the fate of the world hangs in the balance." Similar alarms were rung when the 350 ppm level was passed.

But nobody else noticed anything scary. Four pieces of well-established evidence say that 400 ppm of carbon dioxide in the atmosphere is not a concern.

Firstly, there has been no increase in global temperatures since 1998, despite 16 years of rising carbon dioxide levels and heavy usage of carbon fuels. Clearly, CO_2 is not the main driver of global temperatures.

Secondly, the ice-core records show clearly, with no exceptions, that all recent ice ages have commenced when the atmosphere contained relatively high levels of carbon dioxide. The temperature fell first and then carbon dioxide levels fell. This proves that high carbon dioxide levels do not guarantee a warm globe but could suggest that they may be a harbinger of a coming ice age. Ice will cause far more damage to the biosphere than the even the worst warming forecast.

Thirdly, current levels of atmospheric carbon dioxide are not extreme or unusual. Carbon dioxide reached 2000 ppm in the luxuriant era of the dinosaurs and 10 times current levels (4000 ppm) when the great Devonian coral reefs were flourishing. There is no tipping point into runaway global warming, or we would have tipped eons ago.

Finally, current carbon dioxide levels are just above starvation levels for plants. All vegetation would grow stronger, faster, and be more drought resistant and heat resistant if carbon dioxide levels trebled to 1200 ppm. Such levels are no threat to humans – US submarines operate at up to 8000 ppm for cruises of 90 days. Topping 400 ppm should be a cause for celebration – it shows that Earth is emerging from the cold hungry years of the ice ages.

Viv Forbes,
Rosewood, Qld.

For those who wish to read more:

400 ppm is just a big yawn:
http://www.climatedepot.com/2013/05/14/co2-nears-400-ppm-relax-its-not-global-warming-end-times-but-only-a-big-yawn-climate-depot-special-report/

Past Climates and carbon dioxide levels:
http://www.geocraft.com/WVFossils/Carboniferous_climate.html

Nothing new about Climate Change:
http://carbon-sense.com/2013/11/30/nothing-new-about-climate-change/

Current warming is just recovery from the Little Ice Age:
http://vimeo.com/14366077

Carbon dioxide lags not leads global temperatures:
http://www.co2science.org/articles/V6/N26/EDIT.php

Home truths about carbon dioxide in the atmosphere:
http://www.firstthings.com/article/2011/06/the-truth-about-greenhouse-gases

Carbon Dioxide feeds the world:
http://carbon-sense.com/2010/04/15/carbon-dioxide-time-lapse/

Cheap USB chargers

Can you please clarify the situation with cheap chargers, operating from either USB ports or 230VAC mains supplies? As you are aware, these chargers are the focus of a recent fatality. From news reports so far, the victim was listening to her phone via earphones while using a laptop computer. The phone was powered from the mains supply via a cheap Chinese-made USB charger. There was an apparent flash-over within the charger which resulted in 230VAC being transferred to the earphones; the resulting shock causing death.

The availability of these chargers would seem to be widespread. Indeed by chance, I noted an article "Thinking Inside The Box", on page 76 of the February 2014 issue of SILICON CHIP. In the context of the article, reference was made to a charger operating from either a USB port or 230VAC mains supply. This unit, apparently available for $6 from Hong Kong, looks to be identical to the currently suspect chargers.

Accordingly, SILICON CHIP readers who have adopted this option may well be unwittingly exposed to the hazards of fire or electric shock.

Initial reports seemed to be confined to multi-colour chargers but subsequently ivory-coloured units were also displayed, ie, as in the SILICON CHIP article. My own concern relates to a charger for a "Kindle", also purchased from Hong Kong via eBay. My "Kindle" doesn't have an earphone socket, although I understand that it has some sort of audio feature. But my charger is frequently used unattended, sometimes when we're absent from our home. Is it possible that my cheap charger could flash over and cause a fire? This situation would apply to many people, eg, leaving mobile phones on charge overnight.

As one news report highlights, "approved" chargers should carry a compliance symbol (a circled tick with a triangle around the outside). My "Kindle" charger carries no such marking!

Advice from the NSW Office of Fair Trading is that such potentially dodgy chargers should have their pins bent (I'd waggle the pins and fracture them!) and then discarded. I'd like to be sure of precise identification of dodgy units before taking this drastic step.

Maybe this could be the subject of an article in SILICON CHIP, in the general interest? Meanwhile I'll be very carefully monitoring developments described in print and TV. In due course I assume there will be appropriate consumer warnings.

Brian Graham
Waverley, Vic.

Comment: This is a very hot topic and one on which we hope to do an article.

It could be argued we have gone backwards in terms of electrical safety, with all these switching power supplies which have done away with iron-cored transformers which provided better isolation. Essentially, one should not use a mobile phone, MP3 player etc while it is being charged. And if your home is not protected by RCDs, get them fitted. SC

Number of sockets on an isolating transformer

I noted in an editorial comment to a letter on isolating transformers and in the letter from Peter Chalmers on this same subject, you were unable to find the AS/NZS 3000:2007 reference for the requirements for (1) the non connection of the earth pin of the socket outlet and (2) the provisions required when two or more socket outlets are provided on the output of an isolating transformer.

The letter from Peter Chalmers does give some background on the use of two or more sockets on a common secondary winding of an isolation transformer. However, his observation on the use of a single socket outlet is able to be circumvented by the use of a multi-way power board.

The Australian Standard AS/NZS 3000 does, however, provide for multiple appliances from an isolating transformer common secondary winding and these requirements are detailed in clause 7.4.6 of AS/NZS 3000:2007.

Alan Cuthbert,
Wellington, NZ.

Your house Water Pipes could ELECTROCUTE you!

Do you have RCDs (so-called "safety switches") fitted in your home's switchboard? Do you think that eliminates the chance of electrocution? Well that isn't the case because the copper water pipes in your home could easily become live and dangerous! That is why some people have been electrocuted in the shower . . .

Undoubtedly modern Australian homes have safe wiring when they are first built. They would not be "signed off" as such before occupancy certificates were issued if they weren't.

But corrosion and wiring or plumbing modifications over the years can easily produce a dangerous situation which could cause a fatal electric shock.

It is partly because of the M.E.N. Electrical Wiring System used in Australian homes. M.E.N. stands for "Multiple Earth Neutral" and is the system used for wiring the majority of domestic electrical installations in Australia.

As specified in the SAA Wiring Rules (AS 3000-2007), the mains Neutral wire is connected to Earth at the user's switchboard.

In most houses this means that the 230VAC mains supply is connected from the power pole in the street via two cables, Active and Neutral, with the Neutral wire typically connected to Earth via the consumer's water pipe (or a separate Earth stake).

The Earth connection point on the water pipe is usually just at the point where the pipe enters your house. This is important because you need to examine it occasionally to make sure that the connection is sound. As we will show, that Earth connection is vital to the safety of everyone in your household. Typically, the Active and Neutral wires from the power pole to your house have a capacity of 70 or 100 amps. This means that the maximum electricity consumption (volts multiplied by amps) for the household is nominally 16kW (kilowatts) in the case of 70A mains and 23kW in the case of 100A mains.

Happily, most homes normally use only a small fraction of their installed wiring capacity, although there would be times during winter evenings when it could be easily approached in large households when air-conditioning, a microwave oven, a stove and perhaps one or two other cooking or heating appliances are in use.

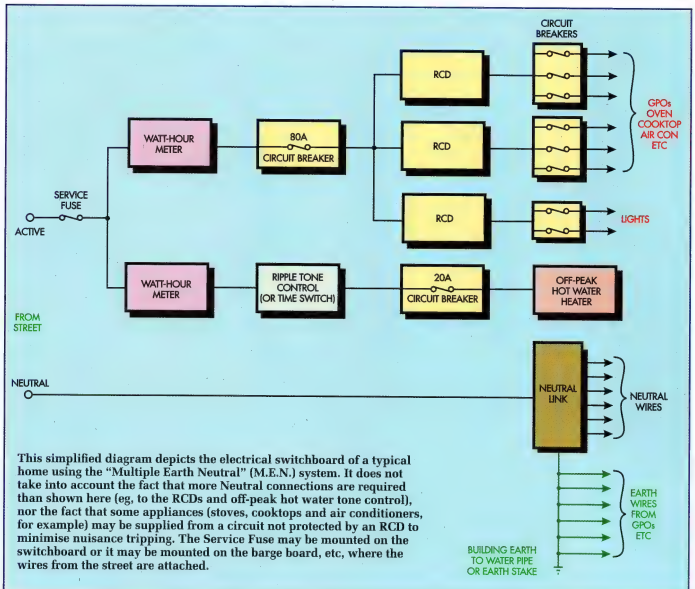
By LEO SIMPSON

Why M.E.N?

"Multiple Earth Neutral" is a system which offers improved safety and lower losses in energy transmission. Let's see why.

In a normal single-phase 230VAC wiring system (which is what most households have), the nominal voltage of the Neutral wire coming into your switchboard is the same as earth, ie, zero volts. But in practice, the voltage is a little higher because all the current from your house and your neighbours' homes inevitably causes a voltage drop in the Neutral cable between your power pole and the nearest substation or pole transformer.

This is because the resistance of the Neutral cable is not zero and the large currents passing through it inevitably means that there is some voltage present on the Neutral line. This voltage



This simplified diagram depicts the electrical switchboard of a typical home using the "Multiple Earth Neutral" (M.E.N.) system. It does not take into account the fact that more Neutral connections are required than shown here (eg, to the RCDs and off-peak hot water tone control), nor the fact that some appliances (stoves, cooktops and air conditioners, for example) may be supplied from a circuit not protected by an RCD to minimise nuisance tripping. The Service Fuse may be mounted on the switchboard or it may be mounted on the barge board, etc, where the wires from the street are attached.

is a loss in the energy transmission system and is part of the reason why, when energy demands are heavy, the mains voltage available at your switchboard is lower than it should be; the Multiple Earth Neutral system mitigates this to some extent.

Because the Neutral wire is connected to Earth in your switchboard, there are actually two return paths for the current passing through the appliances in your home.

Some of the current passes back along the Neutral line, back out to the power pole and thence via the power lines back to your local substation, pole transformer or whatever. The rest of the current passes back via the earth wire to the water pipe and then via good old Terra Firma itself to the substation.

(Editor's note: we have simplified matters here by ignoring the inherent current balance of three-phase power energy distribution systems. For a brief explanation, see the panel headed, "Current flow, three-phase and all that".)

If you are not familiar with the mains distribution system this may all sound like heresy but it is true. Have a look at Fig.1 which depicts the simplified 230VAC mains wiring of a typical modern household installation with electric (off-peak) hot water heating.

This diagram shows the Active and Neutral connections to the switchboard. The Active wire is connected via two watt-hour meters, one feeding the off-peak hot water service and the other feeding the rest of the power circuits in the household.

Following each watt-hour meter is a circuit breaker which is typically rated at around 80A (amps) and is connected via the RCDs (residual current devices) which protect the power and lighting circuits in the household. From there, a number of circuit breakers feed the individual circuits for the stove, oven and GPOs.

By the way, in the Australian wiring standards (AS/NZS3000), power points are referred to as GPOs which stands for General Purpose Outlet.

All the Neutral return wires from the household power and lighting circuits are connected together at the Neutral Link. This also connects to all the earth wires from the power and lighting circuits as well as the main earth wire, which in turn connects to the water pipe or in some cases to a mains earth stake driven well into the ground. It also connects to the Neutral wire which comes directly from the power pole.

On this one pole are the Neutral and three Active phase wires (on the crossbar at top) with the Neutral having the most connections; below that are two cable TV/broadband services and telephone lines. Normally, the phone and at least one cable TV line (Telstra) would be underground but this pole sits in a hole drilled into solid rock. Note that we haven't mentioned an Earth wire – under the M.E.N. system, the Earth connections are virtually always made at the consumer's premises.

(We are ignoring the separate Neutral links which are used for each RCD. These additional links are used because the RCDs monitor the balance between the Active and Neutral currents in their respective circuits).

So it is a fairly straightforward circuit and it would be natural to assume that all the current which comes in via the Active feed wire goes out via the Neutral wire. In other words, the current in the Active wire is equal to the current in Neutral wire.

It ain't necessarily so!

It is possible that as much as half (or even more) of the return current goes via the Earth wire and the remainder goes via the Neutral back to the power pole.

To take a particular example, if you were using a 2400-watt radiator which draws 10 amps from the Active line, 6 amps might go via the Earth wire to the water pipe and the remainder, 4 amps, would go via the Neutral return.

The simple explanation for this is that the resistance of the Neutral cable back to the substation or pole transformer is slightly higher than the very low resistance via the earth path to the same point. Ergo, some current goes via Earth and some goes via Neutral. It can't all go via Neutral.

Having come to terms with this previously unconsidered fact, what does it mean? It means that the supply authorities are able to obtain lower supply losses in the return path than they otherwise would if the M.E.N. system was not used. They also experience less voltage flash-overs from Neutral to Earth during thunderstorms in appliances which are permanently connected.

A common example of this used to occur in stove heating elements. Even though the stove or oven might have been turned off, a lightning strike on a power line would cause many stove elements to break down to chassis.

With the MEN system this is much less of a problem.

Wherein lie the problems?

Corrosion is the first problem. Since many small appliances these days use thyristor power controls there is inevitably a DC current imposed on the mains supply. Some of this current will flow via the connection between the Earth wire and the water pipe. And the very presence of DC will accelerate corrosion which naturally occurs when dissimilar metals are used, as they normally are.

Ultimately, corrosion of the connection between the Earth wire and the water pipe will mean that the connection will be broken. Or if it does not become physically open-circuit, its resistance may be so high as to be useless.

OK, so that means that if you have lost the Earth connection and an appliance such as your washing machine breaks down from Active to chassis, the chassis could be lethal. That is bad enough but consider another possibility which is even more likely and happens quite frequently.

If corrosion has occurred in the connection between your main Earth wire and the water pipe, is it not just as likely that corrosion has progressed in the Neutral connections between your house and the power pole? Of course it is. What that means

Current flow, 3-phase and all that

We have made a number of simplifications in the writing of this article. The first is that we have said that current flows from Active to Neutral or from Active to Earth, as the case may be. In fact, since we are talking about 50Hz alternating current, the current changes its direction 100 times a second.

It is convenient to think of current flowing from the Active line though, because in the words of an electrician we know, "It's the Active line that gets ya. It's the one with the juice!"

The second simplification involves the concept of Neutral current flowing back to the substation, pole transformer or whatever. This ignores the fact that domestic mains power distribution from the power pole has three phases, each of 230VAC (with 120° phase difference between each). In an ideal system, the currents should be balanced so that there is no current flowing in the Neutral line.

Domestic systems are typically single-phase, so appreciable current does flow in the Neutral return.

is that the Neutral return could now have an appreciable resistance and could easily be around 5 ohms or more.

If that is the case, all of the return current will go via the Earth and water pipe. But what if the Earth connection has broken? What that means is that if you now have an appliance drawing 5 amps, the voltage impressed across the Neutral return path from the switchboard to the power pole will be 25 volts AC.

Hmm. So the Neutral link will be floating at 25 volts AC above Earth. And all the earths from the various points in the house are connected to the Neutral link. So every appliance plugged in will have its chassis floating at 25 volts AC above earth. In time, this could get much worse.

So your fridge, washing machine, toaster and microwave oven could all be sitting there silently with their metal cabinets at a substantial voltage above earth. Touch one of those and a properly earthed metal object, such as your kitchen sink, at the same time, and it could be curtains!

It does happen.

Of course, another corrosion scenario is also possible and it also does happen. What if corrosion in the Neutral connection has resulted in high resistance or an open-circuit? In that case, all the current will flow in the Earth. All your appliances will continue to work and will be perfectly safe. Your RCDs will continue to monitor for any imbalance between Active & Neutral currents into your electrical system. No problem.

But all that current is now flowing in your Earth connection. And in many homes, that Earth connection is via your water pipes. If you have an AC clamp meter, your can check this yourself. Just wrap the clamp around the water pipe just where it goes via your water meter, as you can see in one of the pictures in this article. You can see the clamp meter is reading a substantial AC current!

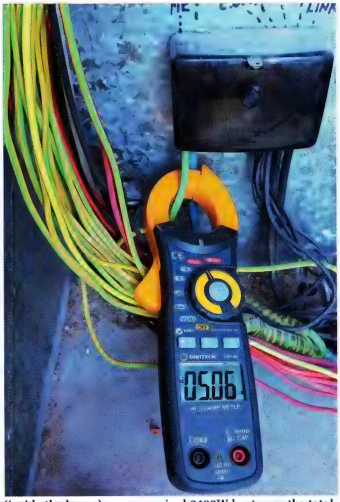
Does this ring alarm bells?

Well, it should. That water meter is a potential death trap!

If a plumber needs to disconnect the water meter, he may be interrupting a circuit in which a substantial mains current is flowing. If the water meter is removed, there could be a very high voltage between the two ends of the pipe and there is a danger that the poor unsuspecting plumber could be electrocuted.

Fortunately most plumbers know about this hazard and before removing a water meter, their standard practice is to bridge around the water meter with a set of car battery jumper leads, before it is removed.

Mind you, plumbers have been known to create a hazard further downstream from the water meter by replacing a length of copper pipe with



If this isn't enough to scare you, perhaps it should be. The load (inside the house) was a nominal 2400W heater, so the total current drawn is just shy of 10A. That's what we'd expect to see on the main Neutral line (the left photo). But it's only 4.32A – the other 5.06A is actually flowing through the (green/yellow) Earth wire in the photo at right. If your Earth connection is in any way faulty . . .

plastic, thereby breaking the Earth connection and creating a shock hazard.

So what might be the likely signs that you have a hazardous condition in your wiring or water pipes? Perhaps the most dangerous is where people receive an electric shock or tingle from the water taps over the kitchen sink, or worse, while in the shower. If this ever happens to you or one of your acquaintances, you should immediately contact your electricity supply retailer. They should have an inspector out to check the situation in very short order. And often they will find in a defect in the Neutral wiring back to the supply in your street.

But you don't have to wait for this dangerous situation to develop. You can make a few checks yourself.

What you should do

Do you know where your main Earth point is?

Take a walk around your house. Where does the water pipe enter the house? That is probably the point where you will find the Earth wire connected via a screw clamp.

If you can't find it, have a look at your switchboard. There may be a note (in white paint) saying where the Earth is.

In some areas where the water service is run in plastic pipe, or the copper pipes do not make intimate contact with the ground (eg, when the pipes are run above ground or on rock) the authorities specify that the Earth connection is made to a long copper-clad steel spike or rod driven at least 1.2 metres into the ground, Alternatively, the Earth connection may be made to a strip electrode at least three metres in length and buried at least 45cm underground.

When you find the connection, inspect it carefully to see that it is sound and not corroded. If the connection is badly corroded you should have it attended to by a licensed electrician.

Use an AC clamp meter

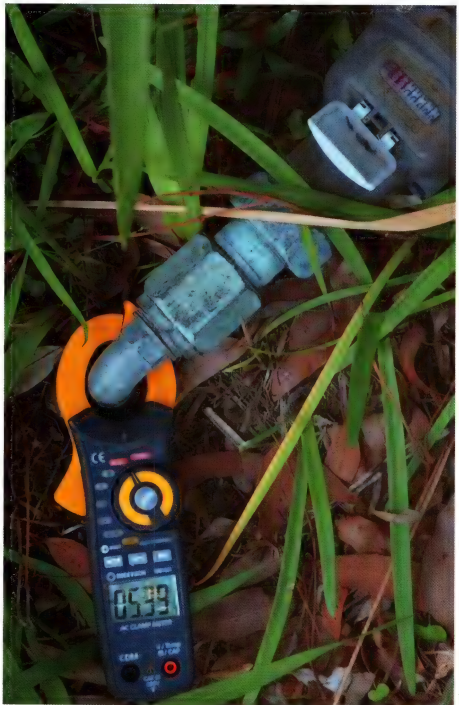
But there is a better way to check the integrity of your Earth connection and that is to use an AC clamp meter. First, you need to have a substantial AC current flowing in your home's wiring and the best way to ensure that is switch on an electric radiator, preferably one rated at 2400 watts because that means that it will pull a current of close to 10 amps.

Switch on and place the clamp meter over the Earth wire to your water pipe or Earth stake. Some AC current is bound to flow and it could be 6 amps or more.

So what if you measure a current of close to 10 amps? That's when the alarm bells should be ringing because that means that you have no Neutral current and no Neutral connection out to the wires in your street. That means that your water pipes and taps could become live and lethal, as outlined above.

If the Earth current is more than say, 5 amps, you have cause for concern. In that case, you should contact your local electricity authority and have them check out your Neutral connection.

Don't do this test during or just after wet weather. When the ground is saturated, more current will tend to flow



This reading of 5.39A in the water pipe between the house and the water meter is not at all atypical – it can often be more. But just imagine if a plumber (or anyone else) disconnected the water meter or severed the pipe – it could be very easily be lethal!

via earth than via the Neutral path.

Warning

Many people will not be qualified or feel confident to make any measurements as described in this article. If they suspect that their electrical wiring is unsafe, they should contact a licensed electrician or the electricity supply authorities.

A number of serious questions remain to be answered. Do the electricity supply authorities have any program for periodic checking of customers' Active, Neutral and Earth connections? Or does the first indication come from the customer, complaining that they "got a tingle from that appliance"? And are plumbers and employees of the various Water Boards instructed to take any special electrical safety measures when disconnecting a customer's water supply?

The simplified diagram of a typical switchboard on page 15 does not show any details of all the Neutral connections which are necessary for the RCDs. This photo shows typical RCD Neutral link connections.

Currents can flow even when the power is turned off!

As part of the preparation for this article, I used a Digitech AC clamp meter (Jaycar Cat QM-1561) to measure Neutral and Earth Currents at my switchboard.

I also measured the current flowing via the water meter and I noticed that much greater currents were flowing in the water meter than could possibly be attributed to my home consumption when the load was only standby power from cordless phones and other appliances.

So while the total consumption was much less than 100W, the current in the Earth was as much as 4A, or more!

I turned off the power at the main circuit breaker and the large Earth current was still there. Checking the Neutral, I found that virtually the same current was flowing in the Neutral. How could this be? This was quite independent of anything in my home. I also measured the current flowing in my next door neighbour's water meter and found that it also had substantial current flowing, even though no-one was home.

At this point I contacted Energy Australia, my electricity retailer, and they sent an electrician out within hours. He first confirmed that about 55% of the load current was flowing in the Earth and the rest via the Neutral. But he used a much larger load current. Instead of simply switching on a 2400W radiator as I had, he over-rode the Zellweger ripple tone control switch to allow the hot-water tank elements to cut in. This gave a total load current of 31A.

He also confirmed that current flows in the Neutral and Earth when the mains supply fuse is disconnected. He said that this is not uncommon and does not necessarily indicate a fault in the household system.

He then proceeded to do a system integrity check with a Fluke 1654B Multifunction Tester and came up with figures of about 0.35 ohms for the Neutral path and 0.3 ohms for the Earth which he then pronounced to be quite safe. The test procedure is according to Australian Standard AS/NZS3017.

(An alternative instrument for this testing would be the Metrel Insaltest 3017 from Emona Instruments [www.emona.com.au] which was reviewed in the September 2008 issue of Silicon Chip).

He was very thorough during the testing, wearing three pairs of gloves, rubber boots and protective goggles which is a mandated procedure.

He also confirmed that anyone finding high currents flowing in the water meter should contact their electricity retailer. Apparently they get most calls of this nature from plumbers or from Sydney Water.

Interestingly, high currents in the water meter can lead to burnt O-rings, leading to a complaint of tainted water from consumers. SC

The Metrel Instalset AS3017 Test Set from Emona Instruments. It's not cheap (in both senses of the word!) but if you're involved in installation or checking of electrical installations, it makes short work of what could otherwise be laborious tests.

Digital Audio File Formats Explained

By NICHOLAS VINEN

In the digital world, there are a lot more ways to store and transmit audio data than there are analog forms. The differences, advantages and disadvantages of these formats are not obvious. Here are some details on the various formats and their differences.

PCM, MP3, WAV, FLAC, AAC, OGG, WMA – these are all pretty cryptic names for common audio file formats. So if you want to store audio on your computer, phone etc, which format should you use and why? It depends on a number of factors as each format comprises a different set of compromises.

Digital audio basics

All digital audio ultimately starts as an analog signal (eg, from a microphone) and also ends up as an analog signal; typically, going to an amplifier to drive a set of speakers or headphones. An analog-to-digital converter (ADC) converts the original analog signal to a digital format while at the other end of the chain, a digital-to-analog (DAC) converter turns it back into analog.

The digital output of the ADC is usually some form of Pulse-Code Modulation (PCM) and this can be regarded as the most basic form of digital audio. Two common examples of digital audio formats based on PCM are the Microsoft WAV file format and CD audio.

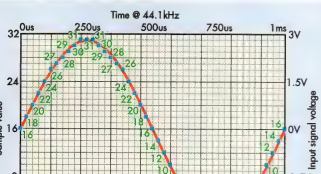


Fig.1: how a 1kHz analog sinewave (red) is converted to PCM values (sequence of green numbers). This shows 32 voltage steps when a real PCM waveform normally uses at least 65,536. The voltage is sampled at a constant rate (here, 44.1kHz) and the nearest value for the voltage at that point (blue dots) is stored as the next number in the sequence.

Fig.1 shows how a continuously varying analog signal (red) is converted to a set of data points (blue). The horizontal axis is the timebase and the vertical lines represent sampling periods which occur at fixed intervals. The number of such sampling intervals per second is known as the sampling rate and is typically at least 44.1kHz for good-quality sound reproduction.

The vertical axis represents voltage and this too is divided up into a number of equal intervals. For CD audio, there are 65,536 such intervals representing a total voltage of about 6V, to handle signals up to about 2.1V RMS. Each interval therefore covers a range of about 0.1mV. The number of voltage steps is the resolution and since $65,536 = 2^{16}$ this is known as 16-bit audio (note: Fig.1 has a lot less steps for the purposes of illustration).

At each sampling period, the analog-to-digital converter finds the hori-

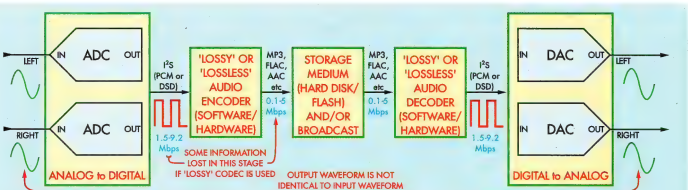


Fig.2: compressing digital audio adds an extra step into both recording and playback. Once analog data has been digitised (and possibly mixed), it passes through an encoder which produces an output bitstream at a lower rate than its input. This can then be more easily transmitted or stored. Later, before being played back, the data passes through a decoder which reconstructs the PCM audio data (or a close facsimile) to be sent to the DAC.

zontal line closest to the input signal voltage at that time and since each line is numbered, by storing this series of numbers, we form a digital approximation of the waveform shape (blue dots). The storage required for this data is the product of the number of bits of vertical resolution, the sampling rate and the number of channels. So for CD quality audio this is 16 x 44,100 x 2 = 1.4Mbit/s or 172.266KB/s.

Why 44.1kHz? This frequency was chosen for historical reasons as it divides evenly into PAL and NTSC frequencies, allowing easy synchronisation with video tape. The important thing is that it's more than twice the highest frequency humans can hear (~20kHz) so the Nyquist limit is high enough (more on that later) and the anti-aliasing filter has a sufficiently large 4.1kHz transition band.

At this point, you may have noticed that some of the blue dots in Fig.1 are not precisely on the red curve due to the limited voltage and time resolution. As a result, if you drew a line through these points, it would not be a pure sinewave like the input.

But the DAC has a 'reconstruction filter' which smooths the output to give a result very close to the input signal despite this, as long as the input only contains frequencies up to the Nyquist limit, which is half the sampling rate. In this case, that means frequencies up to about 22kHz are reconstructed almost perfectly.

Experience tells us that with a good-quality ADC and DAC, most people can't hear any imperfections in CD-quality audio recordings. There are arguments to be made that higher sampling rates and bit depths (eg, 96kHz and 24-bit) have certain advantages, hence formats such as DVD-Audio and SACD, as described below.

However, there is a further issue to consider and that is that 172KB/s of data results in quite large storage requirements. A typical CD holds up to 72 minutes of audio with a 720MB capacity. If you have a 32GB SD card, that would hold about 40 full CDs worth of audio; more if the CDs weren't entirely full (but some CDs can contain up to 80 minutes/800MB).

In order to fit more recordings into the same amount of space, newer formats which require less storage have been developed in the last 20 years. With those formats which gain the most dramatic reductions though, small errors are introduced in the reconstruction process. These are known as 'lossy' compression formats, because there is some loss in audio quality. However, 'lossless' audio compression can also be used, to reduce storage requirements modestly without this drawback.

Fig.2 shows a typical audio chain, from an analog recording (eg, an old tape master) through to a digital stream which is then compressed, stored and/or transmitted, then decompressed and converted back into analog audio for amplification.

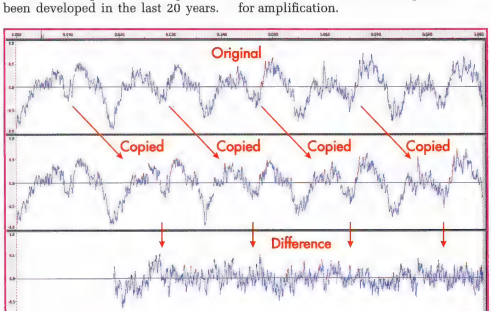


Fig.3: at top is a 90ms snippet of audio from a music CD. Below this we have copied and pasted each cycle over the subsequent cycle as a crude method of 'predicting' the shape of the audio based on previous samples. The difference, at bottom, shows that the error ('residual') with even this crude prediction method has significantly less amplitude than the audio signal itself and thus requires less storage space.

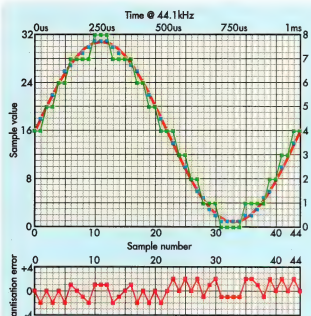


Fig.4: an example of quantisation, which can be applied to residuals or other less important signals to reduce the amount of storage space they require. The number of vertical divisions is reduced; in this case from 32 to 8 and the nearest points are selected instead. The resulting quantisation error is shown at bottom. Normally, though, this is applied to spectral (frequency domain) data rather than time domain data as the deleterious effects are less severe.

So just how much does lossy compression affect the sound and are you willing to put up with that in exchange for fitting more audio? And if you are very fussy, just how much audio can you fit into a limited amount of space?

Lossless compression

There are a few common 'lossless' audio CODECs (encoders/decoders) available. Perhaps the most common is called FLAC, or Free Lossless Audio Codec. Like most lossless CODECs, FLAC typically achieves a 40-45% reduction in storage requirement over PCM without affecting audio quality at all. Other similar CODECs include Apple Lossless, WavPack, TAK and APE but the differences are minor.

If you aren't interested in the details of how this is achieved, you can skip right ahead to the next section.

Many readers will be familiar with compression programs such as "ZIP" and "RAR" which can reduce the size of many types of file, sometimes quite substantially. Unfortunately, if you try to ZIP up a PCM audio file (eg, WAV format), you will save little if any space. That's because despite PCM audio containing quite a bit of redundancy, the general-purpose pattern matching algorithms used in archiving software such as ZIP are not effective at identifying and eliminating it.

To realise lossless compression for audio, we have to consider the nature of the signal itself. For a start, while the vertical scale of the PCM data has to be large enough to encompass the peak signal amplitude, much of the time the signal level is much lower than this; in other words, most audio has significant dynamic range. During the quieter passages, PCM 'wastes bits' (or fractions of bits) which are always zero but are nevertheless stored.

So one simple (but limited) approach to lossless audio compression is to create a PCM-like file format where the bit depth (resolution) can vary over time, to save bits by taking advantage of amplitude variations in the signal. FLAC effectively does this, using a technique called "Rice coding". But that only gives modest gains in space efficiency; perhaps 10% at best.

A more advanced approach is to realise that audio signals tend to be quite repetitive and while subsequent cycles of a waveform are almost never identical to the previous cycle, they are often quite similar. So if you can use one cycle of audio to 'predict' the next, you only have to store the error between the prediction and reality. By then applying that difference during decoding, you can reconstruct the next part of the waveform exactly.

This error signal is known as the 'residual' and it is normally much lower in amplitude than the signal itself. The compressor can store the 'prediction' parameters, which take little space, and since the residual's amplitude is low, the aforementioned dynamic bit depth coding will give a much greater reduction in storage space.

This process is illustrated with a typical audio fragment in Fig.3. All we have done is taken a 90ms snippet from a music CD (top), then created a predicted version (middle) by simply copying each previous cycle to form the next; something that a decoder can easily do, since it has access to past audio samples.

The bottom panel shows the difference between these two signals. As you can see, it's much lower in amplitude than the original and can thus be stored much more efficiently, despite the crudeness of our approach.

Of course, what FLAC and other lossless compressors do is much more advanced than this. For example, they can try multiple different prediction methods for each section of audio and store the results of whichever takes up the least number of bits. But the general principle is the same.

Other lossless methods

Meridian Lossless Packing (MLP) is a commercial lossless CODEC that is used for DVD-Audio. This is slightly more space-efficient than FLAC but it is a proprietary, patented system, compared to FLAC which is free to download and use (including the source code). FLAC is also somewhat faster, especially to decode. There's a lot of detailed information on how MLP operates at www.meridian-audio.com/w_paper/mlp_jap_new.PDF

Ultimately, there isn't much practical difference between FLAC and the other lossless CODECs, including Apple Lossless (ALAC), except for popularity. Apple computer users will find their software has better support for ALAC while Windows/Linux users will be better off with FLAC. Apple audio player hardware such as iPods and iPhones also support ALAC while other devices, including Android phones, typically use FLAC.

Lossy compression

With lossless compression, you can fit around 60 CDs worth of audio onto a 32GB SD card rather than 40 CDs worth. That's an improvement but it is possible to do better, using a lossy compression method.

One way to do this would be to use the same method as FLAC but 'quantise' the residual. That means effectively rounding some of the residual values up or down, in order

to create less possible sample values. Less values take less bits to store, saving space (see Fig.4). This is not a particularly good approach but it would work; since the residual values are usually small, the error signal introduced (shown in red on Fig.4) would also be small.

To get really good compression ratios (ie, increase the ratio between the original PCM data size and the compressed data size), more advanced techniques are required. The first lossy compression method with very high compression and good audio quality was MPEG-2 (Moving Pictures Expert Group) Audio Layer III, better known as "MP3". This was developed by the Fraunhofer-Gesellschaft research institute in Germany in the early 90s.

MP3 followed on the heels of MPEG-1 Audio Layer 2 (MP2), formalised in the late 1980s. MP2 is a less advanced coding method which has a worse compression ratio. However, it also results in less audible degradation and is still in use today for broadcasting, as it is simpler (and thus faster) to encode and decode than MP3.

The added complexity of MP3 is in its heavy reliance on a psychoacoustic model. This takes advantage of psychoacoustic masking, a property of human hearing whereby tones at certain frequencies can make simultaneous tones at other frequencies but of lower amplitudes inaudible ('masked'). In other words, if both tones are present in a signal, depending on the relative levels, the human brain will perceive the louder one but not the other.

Thus, it is possible to do a spectral analysis of the audio data and 'chop out' certain signal components (frequencies) without (in theory, at least) affecting how it sounds. This is illustrated in Fig.5. Note that the tones don't necessarily need to be simultaneous; if one comes immediately after the other it may still be masked and this is referred to as 'temporal masking'.

The resulting simplified spectrum can then be quantised (as explained earlier), re-ordered and compressed using a standard 'entropy coding' method (such as Huffman) to give a much smaller amount of data than the original PCM. This is usually done by chopping the PCM audio data up into variable-sized overlapping blocks and then compressing them separately.

Another option to achieve good compression with reasonable sound

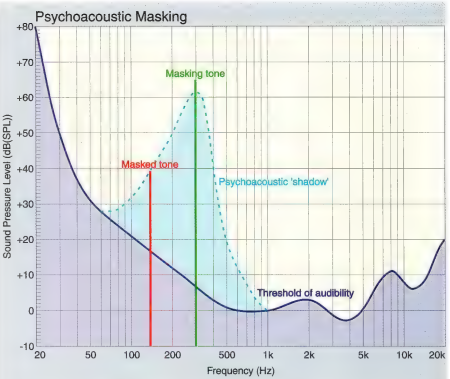


Fig.5: an illustration of psychoacoustic masking. Tones with amplitudes below the threshold of audibility (mauve) are always inaudible but when loud tones are present (eg, 300Hz @ +65dB as shown in green), even tones above the audibility threshold can be masked and generally not perceived as audible. In this case, the 150Hz +39dB tone (shown in red) is within the other signal's "shadow" and thus could theoretically be removed without changing the overall sound.

quality is to separate the spectrum out into the important parts, which the listener is expected to hear, and the unimportant parts which will be partially or completely masked and then decimate the latter more heavily using a more severe quantisation scheme.

During playback, the compressed frequency-domain audio blocks are unpacked and converted back into time domain data. The snippets of reconstructed sound are then joined back together using a 'windowing' method to get rid of any discontinuities caused by the imprecise storage method, ie, where the signal at the end of one block wouldn't necessarily end up at the same voltage as the start of the next block. Windowing takes advantage of the overlap to smooth these transitions.

MP3 also uses the similarities between the two channels in a stereo recording to reduce the size, storing them as a sum and (lossy) difference with a technique known as "joint stereo" (using a method such as 'intensity coding' or 'mid/side coding'), thereby saving further space.

The overall amount of compression varies, depending on how aggressively the psychoacoustic model removes 'redundant' signals and also by controlling the amount of quantisation of the resulting data. In practice, for MP3, the reduction in size ranges from about 77% (320kbps) to 93% (96kbps). At 96kbps/s, there will be a rather noticeable impact to audio quality; at 320kbps/s, not so much.

Note that "kbps" refers to kilobits per second and may also be written "kbit". To convert from kilobits per second to kilobytes per second, divide by eight, ie, 128kbps = 16kB/s.

MP3 compression thus allows for something like 4-10 times more audio to be stored in the same amount of space as raw PCM. Or to put it another way, 250-500 full CDs can fit onto a 32GB SD card with reasonable sound quality. That's quite an improvement!

What's the catch?

So what's the catch? Well, if you're listening to relatively high bit-rate MP3 files on a noisy bus or in a car, you probably won't tell the difference

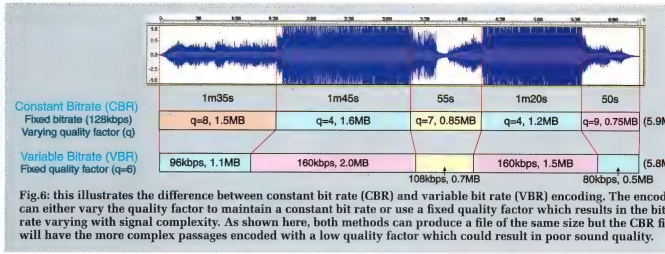


Fig.6: this illustrates the difference between constant bit rate (CBR) and variable bit rate (VBR) encoding. The encoder can either vary the quality factor to maintain a constant bit rate or use a fixed quality factor which results in the bit rate varying with signal complexity. As shown here, both methods can produce a file of the same size but the CBR file will have the more complex passages encoded with a low quality factor which could result in poor sound quality.

between it and the original recording – even with a decent car audio system. But with a proper hifi set-up, the difference between an MP3 and a CD can be stark for critical listeners. Some more recent lossy CODECs claim to do a better job of reproducing CD quality; more on this below. But if you're a discerning listener with reasonable hearing acuity, lossless compression is still your best choice.

Variable vs fixed bit rate

When a lossy compression algorithm is applied to normal audio data, even if each block of raw audio data processed is the same size, it will generally produce compressed data blocks of varying size. That's because the complexity of the audio signal varies over time.

For example, a cymbal clash contains a wide range of frequency components and so will not compress anywhere near as well as, say, a bass guitar by itself. Many audio files also contain short gaps of (near) silence, which may not be obvious during listening.

So while the PCM data is recorded or played at a fixed rate, the natural compressed data stream naturally has a varying rate.

Sometimes, this is undesirable – for example, in a broadcast, there will be a fixed amount of bandwidth allocated to audio. The maximum compressed data rate must not exceed this and while smaller blocks could be padded to fit, that would simply waste bandwidth.

In this case, the best solution is to adjust the 'lossiness' of the compression algorithm block-by-block, in order to produce compressed data with a more-or-less fixed bit rate and then use padding to make up the difference; see Fig.6.

This also has the advantage that the ratio between the uncompressed and compressed data is fixed. For example, if you are compressing CD-quality WAV files to 192kbps MP3 files, you know that the MP3 files will be exactly 192kHz ÷ (44kHz x 16 bits x 2 channels) = 13.6% the size of the originals.

However, there's little reason to do this if you are simply creating files to store on, say, a phone or PC. In this case, it would make more sense to use a fixed quality level and let the bit rate vary. This is known as 'variable bit rate' encoding or VBR.

With VBR, some files will have a higher compression ratio and some lower, depending on the content. However, for a given quality setting (which determines psychoacoustic masking aggressiveness, quantisation factors, etc), the variation is generally only of the order of 25%.

MP3s ain't identical

You might think that if you used two different pieces of software to produce similarly sized MP3 files from the same CD or WAV file source, they would sound essentially the same. But this isn't necessarily the case. During MP3 encoding (or indeed, any lossy encoding), the encoder has thousands of decisions to make for each block of audio processed in order to produce the smallest output which loses the least information.

For example, during the psychoacoustic modelling process, there are many signals which could be removed from the sound in different combinations and different encoders may choose to remove different frequencies to achieve the desired reduction in signal complexity.

There is also a speed trade-off as encoders which take longer may have more time to 'explore' all the possible combinations of masking, quantisation etc and determine the best combination to achieve the required compressed data size. There are also many different metrics which the encoder can use to determine which is the 'best' outcome. Therefore, a more carefully designed MP3 encoder can produce significantly better sounding MP3 files at the same size (or even smaller!) as a poorly written encoder.

So if you're going to compress hundreds of CDs to MP3 format, it pays to do your research first and pick encoding software which gives the best quality output. This may even allow you to use a lower ultimate bit rate for the same sound quality, thus fitting more data on to your storage medium.

While this is a subjective evaluation (and readers are invited to do their own research via Google), some encoders are generally considered superior. One of the better-regarded MP3 encoders is the free, open source, multi-platform "LAME". Even this, though, has many different settings which give different results. Suggested quality levels for a good size/sound quality trade-off are the "-V0" (~245kbps), "-V1" (~225kbps), "-V2" (~190kbps) or "-V3" (~175kbps) options; see http://wiki.hydrogenaud.io/index.php?title=Lame

Advanced compression

Since MP3 was formalised in 1995, a number of improved CODECs have been developed. In some cases, the

aim was to produce an algorithm with a similar compression ratio to MP3 but with better audio quality. In other cases, the aim was to produce better compression without such objectionable artefacts as are present in low bit rate MP3 files (<128kbps).

One of the more successful codecs has been AAC and its variations, AAC+ and HE-AAC. These were developed as a successor to MP3 for the MPEG-4 standard and have also been adopted by Apple for use with iTunes. AAC is generally regarded has having better audio quality than MP3 at the same bit rate while AAC+ is optimised for lower bit rates and gives little or no benefit at settings of 128kbps and above.

In fact, AAC+ is generally inferior to both MP3 and AAC at higher bit rates (192kbps+). While many consider 128kbps AAC to give good sound quality, we feel that as with MP3, you really need 192kbps to even get close to CD quality. Note that DAB digital radio uses AAC encoding and DAB+ uses AAC+, so the same comments apply.

Unfortunately, few DAB+ radio stations in Australia are encoded at rates above 64kbps! The result is that they sound inferior to a simultaneous FM broadcast of the same program (assuming good reception).

Ogg Vorbis

Another post-MP3 format is Ogg Vorbis. This was developed specifically because MP3 is a patented algorithm and Fraunhofer charge a fee for using the technology. In contrast, Ogg Vorbis is a free, open source alternative which can give superior audio quality to MP3 at some (usually higher) bit rates.

One source of subjective comparisons of lossy audio CODECs and encoders is http://soundexpert.org/encoders We have graphed the information from this website and smoothed it considerably, to give Fig.7. This suggests that AAC is the best choice above 224kbps, Vorbis the best between 112kbps and 224kbps, and AAC+ the best choice below 112kbps.

Note the large increase in perceived quality above 224kbps, suggesting that if you want to play lossily compressed files through a hifi system, the best compromise between quality and size is probably somewhere around 256-288kbps and thus AAC is the CODEC to use. This gives a compression ratio relative to CD-quality PCM audio data of around 5.5:1 – still very worthwhile.

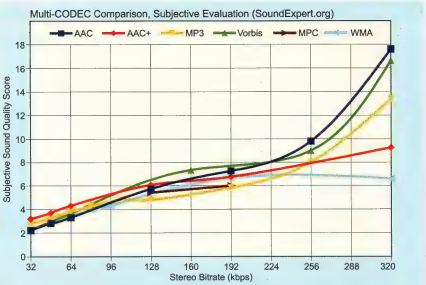


Fig.7: a comparison of the subjective scores awarded to audio samples compressed with different audio CODECs and varying bit rates. While this can only be considered a guide, it shows the perceived audio quality of most lossy CODECs goes up significantly above 256kbps and also that certain CODECs seem to sound better than others for particular ranges of bit rates.

To get an idea of what these bit rates really mean, refer to Table 1. This shows how much audio you can fit, in terms of hours or average CDs per GB. This applies both to storage (ie, how much you can fit on an xGB flash drive) and transmission (ie, how much bandwidth you will use streaming digital radio at a specific bit rate).

Encapsulation

When you have a digital audio stream, it needs to be "encapsulated" somehow to be stored. For example, PCM audio can be encapsulated in the WAV format which in addition to the PCM audio data itself, includes information at the start of the file indicating the sampling rate, bit resolution, number of channels and length.

CD audio ('redbook') also uses the PCM format but it involves a more complex encapsulation for two reasons: (1) it adds error checking and correction (ECC) information so that small scratches or divots on the surface of the CD do not render it unplayable (and hopefully won't affect the sound at all); and (2) it provides feedback to the user as to which track they are listening to, how far they are into the track and allows seeking and skipping to specific tracks.

As a result, each 'sector' of a CD, containing 2352 bytes of PCM audio data, is actually 3234 bytes in size. The extra 882 bytes per sector includes two 392-byte ECC blocks and 98 bytes of side-channel/control data. There are 75 sectors of data for each second of audio. A redbook audio CD also has a table of contents, listing the location of up to 99 tracks along with their length, the duration of any pauses between tracks etc.

Encapsulation can also include the ability to store track names, authors, composers, genre etc. For example, CD audio includes the ability to store track names using the CD-Text extension although few discs contain such information.

Other types of digital audio encapsulation for storage include:

- **FLAC:** this can be encapsulated in its own simple container format (.flac), or it can be stored within an "Ogg" file, which is the same encapsulation as used for the Vorbis CODEC which also supports metadata (track name, author, etc).
- **MP3:** can either be stored in an "elementary stream" (.mp3 file), with optional ID3 metadata tag at the beginning or end, or in an MPEG stream, possibly along with video data.
- **AAC:** can be encapsulated in an MPEG-2 or MPEG-4 stream. Also used for DAB+, DVB-H or can be contained in an "ISO base media file" (.aac file).
- **Vorbis:** generally either appears in an Ogg file (with or without Theora Video) or in a Matroska file, which is intended to be a flexible multimedia

Table 1: Storage Required For Typical Audio Bit Rates

Bit rate	Hours/CDs per GB	Hours/CDs per 32GB	Data per hour/CD
64kbps	37	1165	28MB
96kbps	25	775	41MB
128kbps	19	580	55MB
160kbps	15	466	69MB
192kbps	12	390	82MB
224kbps	10	333	96MB
256kbps	9	291	110MB
288kbps	8	259	124MB
320kbps	7	233	137MB
1.4Mbps (CD)	1.7	53	606MB

container format (akin to Microsoft's AVI).

Having been read from the source file or media, the same data may then be transmitted to a different piece of equipment or a different IC within the same device. This is generally done by re-encapsulating the extracted digital audio data in one of several transmission formats:

- **S/PDIF:** a two-wire format using biphase encoding, intended for transmitting audio data between media players, amplifiers, receivers and so on. S/PDIF can carry linear PCM, Dolby Digital, DTS and other formats, along with metadata describing the contents of the data and its source. The optical version of S/PDIF is known as TOSLINK.
- **I²S or one of its variants:** a simple method for transmitting PCM audio data between ICs within a device, similar to SPI. Typically involves a bit clock line (typically 32 or 64 times the sampling rate), word clock (at the sampling rate), data bit transmit and/or receive lines, plus a master clock which is typically between 128 and 1024 times the sampling rate.
- **MPEG transport stream:** while this is used as a file format (with an extension such as .mpg or .mp4) it is also intended to be used as a transmission format and is used for digital TV, among other purposes. MPEG streams can contain video, audio or both and can also include subtitles and other metadata.

Multi-channel formats

Multi-channel formats compress three or more channels of audio for "surround sound". They usually have a relatively high bit rate (eg, 384kbps+) as they are intended for use with movies where significant degradation in sound quality is not acceptable. However, multi-channel formats are also sometimes used for music recordings, to give a more 'immersive' or 'live' sound.

With some exceptions, these formats generally have inferior sound quality to CD-quality PCM. Of the two most common 5.1 channel formats, DTS is usually considered to have superior quality to Dolby Digital (AC3) at the same bit rate.

As with stereo CODECs, multi-channel formats take advantage of the similarity in content between channels to achieve good compression. They also use the fact that some channels only operate over a limited range of frequencies, especially the subwoofer or "low frequency effects" channel (the ".1" in 5.1 or 7.1).

The sound quality of the left and right channels is generally the most critical as these carry most of the music; centre is used mainly for voice while surround channels mostly carry effects so degradation on those channels is less objectionable. Thus, the bit rate of a 5.1-channel audio stream is usually no more than about twice that of a stereo recording.

Dolby Digital 5.1 and DTS 5.1 were the most common multi-channel formats in the early days of DVDs. More recently, with the introduction of HD-DVD (now obsolete) and Blu-ray, both Dolby Labs and Digital Theatre Systems have come up with higher quality formats that support even more channels, eg, 7.1 surround sound with a total of eight channels.

More recent multi-channel formats such as Dolby Digital Plus, Dolby TrueHD, DTS Neo, DTS 96/24 and DTS-HD increase audio quality through higher bit rates and in some cases, use lossless compression. However, the general principle remains the same.

DVDs use an MPEG-2 stream and allow linear PCM, MP2, AC3 or DTS compressed audio data to be interleaved with the video. Multiple audio streams can be interleaved, to support different numbers of channels or languages.

DVD-audio adds the ability to carry Meridian Lossless Packing (MLP) audio data at higher sampling rates and bit depths such as 24-bit 96kHz or 24-bit 192kHz. DVD-audio players thus generally have higher-quality DACs plus the ability to decode these streams. In addition, DVD-audio discs can contain Dolby Digital and DTS tracks.

Non-PCM audio data

While virtually every digital audio format is either based around PCM or derived from PCM, there are other formats. Super Audio CD or SACD is one of these and it is based on Pulse-Density Modulation Encoding (PDME) which Sony and Philips refer to as Direct-Stream Digital (DSD).

Rather than using a sampling rate of 44.1kHz, they use 2.8224MHz (ie, 64 times higher) but each sample is just a single bit. Noise shaping is used to allow the one-bit data stream to accurately encode an analog signal at a much lower frequency.

The reason for using PDME rather than PCM is that most modern DACs are the Delta-Sigma type, which typically comprise a 4-bit DAC operating at a similar frequency, ie, some multiple of the incoming PCM data sampling rate. The advantage of this approach is that it's much cheaper to fabricate a 4-bit DAC with good linearity than a 16-bit DAC. In addition, the much higher noise frequency means that the output analog filter doesn't need to be anywhere near as steep and so it can be much simpler.

The logic therefore is this: if the DAC is going to have to convert the PCM to some form of PDME internally, why not simply store and transmit the data in this format? It certainly is a valid approach but one criticism levelled at DSD is that it's much more difficult to process audio in this format than PCM data, and converting between PDME and PCM is not simple.

Perhaps it is for this reason that DVD-audio uses traditional PCM encoding, although with higher sampling rates and bit depths. SC

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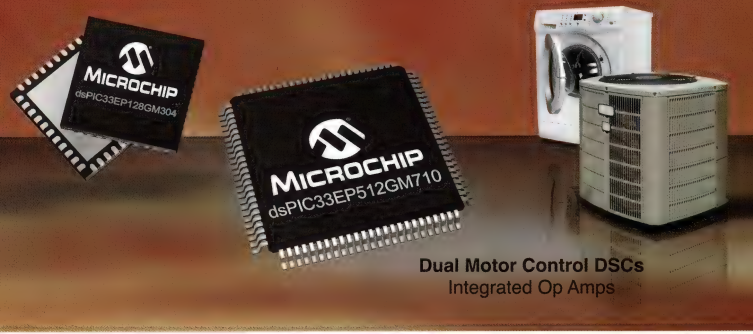

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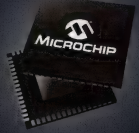

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There's absolutely nothing wrong with this currently legal, dual channel, dual-diversity Digitech wireless microphone system from Jaycar . . . except that using it after December 31 could land you with a fine – all because it operates in what will be a banned frequency range. Jaycar have now replaced this with a legal (520-694MHz) model.

By
ROSS TESTER

Is your Wireless Microphone soon to be ILLEGAL?

A huge proportion of the wireless microphones now being used in Australia will soon lose their licences to operate. If you keep using them after December 31st, you could be liable for a big fine. We return to this rather thorny subject.

We covered the changes to Wireless Microphones in some detail in the June 2013 issue but with the December 31 deadline looming, it is timely to look again at the reasons for the changes in legislation and regulations which could affect a lot of clubs, non-profit organisations and other users of so-called 'plug and play' wireless microphones.

First, a brief recap: the Labor Government sold off a large chunk of the UHF band, previously occupied by analog TV stations, as part of the Australia-wide move to digital TV. Digital TV doesn't require anything like the bandwidth of analog, so those stations which used to transmit in the 694-820MHz band have all been "restacked" (or the very last are in the process of moving) to the 520-694MHz band.

This so-called 'Digital Dividend' reaped billions of dollars for the Government as it was sold off to telecommunications organisations for 4G data/voice expansion.

The problem was, and is, that a huge number of wireless microphones and other wireless audio devices, particularly the lower-end models, also shared the 694-820MHz band, slotted in between the old UHF TV transmitters.

It is these wireless microphones (and other wireless devices) which will become illegal to use from January 1st, 2015.

How many?

Quite a few years ago, the industry association put the number of wireless microphones in use in Australia at above 300,000.

Just about every club, public and private hall, reception centre, theatre group, place of worship, sporting arena, shopping centre and store, local council, sports coach and fitness/dance instructor, hotel and restaurant and many other venues have one or more (in some cases many more) wireless microphones.

One local club I am familiar with has *six*, used for wedding receptions, functions and sports events. In the main, venues like these use the lower-cost models which, while perhaps not offering the fidelity and flexibility of more

professional models, are fine for the intended purpose. They're convenient, allow freedom of movement without cords to trip over and the better ones provide a quality of signal that's every bit as good as fixed microphones.

Until the last couple of years or so, the vast majority of these wireless microphones used that higher (694-820MHz) band and this is still mainly the case for the lower-cost mics which were sold in their tens of thousands by music stores, electronics stores, at markets and, in particular, online.

There are many thousands more professional wireless microphones in use which operate at much higher (legal) frequencies – mainly around 1.8GHz – but these are not affected by the changes.

Got a Portable PA?

We're not just talking about wireless mic and receiver setups: huge numbers of "portable PA systems" have been sold over the years, many of which have an inbuilt wireless microphone receiver. You often see them used in shopping centres by store spruikers; buskers use battery-powered models, they're used for public meetings and so on.

This Okayo portable PA system may be OK (o!) but more than likely is not! It was sold with a wireless mic frequency of between 640MHz (just OK) and 865MHz (not OK!).

Again, the vast majority of these will become obsolete – the amplifier itself may still be quite OK but the wireless microphone connecting to it will not. Some of these may be upgradeable but most will not. The only option to stay legal will be to use a corded microphone or to connect a new (external) wireless mic receiver to the "line in" or "aux" input.

Incidentally, it was one of these systems which twigged us to the whole sorry saga early last year, when a relative who used a local council portable PA asked us if we'd heard that they were soon to be outlawed. At that stage, we hadn't – so much for the industry-wide consultation!

By the way, Bluetooth wireless mics, which are used with quite a few portable systems, are not affected. They will remain legal as they operate in the 2.4GHz band like all other Bluetooth devices.

Criticism

Following our June 2013 report, we were roundly criticised by the association representing the professional end of the market for saying that most wireless mics were in the upper, and soon to be withdrawn, UHF band.

They claimed that their association had worked closely with the Government (and ACMA, the regulatory body), to ensure that their members knew the new requirements and only sold 'future proof' equipment, operating in that 520-694MHz band.

And we're sure they did. But as late as last year, when our report was written, we found that many retailers were still selling 694-820MHz equipment. But that wasn't the real problem. It was all those tens (hundreds?) of thousands of users who had bought, in good faith, lower-cost wireless microphones which would be outlawed – without any form of recompense or subsidy.

To compound this, we knew from experience that huge numbers of wireless microphones weren't sourced from "professional" suppliers (the ones who knew the new rules) but instead were purchased online from sources like Gumtree, ebay, Trading Post etc.

Even as late as last month, you could still buy significant numbers of high-UHF band wireless microphones online, without the compulsory warning attached that they would not be usable from January 1 2015 (that warning is an ACMA requirement, part of the LIPD licence under which these things operate. It is that LIPD licence that will be withdrawn on December 31).

Some of that equipment is being offered for less than (often *much* less than) $100. Compare this to the professional gear used by TV studios, entertainment venues and the like, which is often *many* hundreds of dollars, if not thousands.

Perhaps just as disturbing is the number of "Professional VHF" (whatever that means!) systems still being flogged online. Try using one of these in a capital city even now, with the VHF band from 181 to 230MHz wall-to-wall with digital TV and DAB+ radio. There are also a handful of country areas which have retained VHF TV – the Manning Valley (NSW lower north coast) is one such area.

Even if your VHF Wireless Microphone is below 180MHz (and a lot of the ones we've seen even now for sale are, especially around 170MHz or so) you're still in trouble, because with the digital TV restacking the old VHF channels 0 to 5A (56 to 181MHz) have all gone and the LIPD licences for equipment using those frequencies have also been withdrawn.

By the way, while the Government has made no effort to recompense existing users of soon-to-be-banned equipment, quite a number of suppliers have put together "trade-in" deals. Most of these offer the more expensive "pro" equipment but they could be worth a look if the trade-in makes the deal sweet enough.

Local TV translators can still cause problems

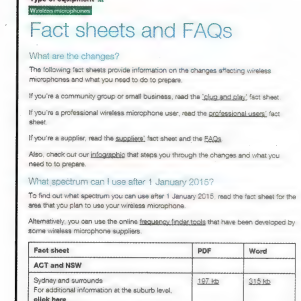
With the move to digital TV and the re-stacking of channels, a lot of areas are not served by the main city, high-power transmitters but by lower-power translators.

So even if you do buy a legal (520-694MHz) wireless microphone you could still be in trouble, because part of the LIPD licence specifies that you must not use any frequency which a local broadcasting service occupies.

"Local" might cover a lot greater area than you think – for example, many TV viewers along Sydney's northern beaches receive their TV signals only from Bouddi Head, on the NSW Central Coast.

Similarly, many residents in Sydney's south have to watch TV programs from the Wollongong area. In both these examples, terrain prevents signals from the Sydney transmitters from avoiding the 'digital cliff'. You've either got a picture or you haven't; with digital TV there's no 'in-between'.

There are several websites which show the areas digital TV stations are, or very shortly will be, transmitting in along



Type of equipment
Wireless microphones

Fact sheets and FAQs

What are the changes?

The following fact sheets provide information on the changes affecting wireless microphones and what you need to do to prepare.

If you're a community group or small business, read the 'plug and play' fact sheet.

If you're a professional wireless microphone user, read the 'professional users' fact sheet.

If you're a supplier, read the 'suppliers' fact sheet and the FAQs.

Also, check out our infographic that steps you through the changes and what you need to do to prepare.

What spectrum can I use after 1 January 2015?

To find out what spectrum you can use after 1 January 2015, read the fact sheet for the area that you plan to use your wireless microphone.

Alternatively, you can use the online frequency finder tools that have been developed by some wireless microphone suppliers.

Fact sheet	PDF	Word
ACT and NSW		
Sydney and surrounds For additional information at the suburb level, click here.	197 kb	215 kb
ACT and Southern Tablelands	208 kb	70 kb
Central Tablelands and Central Western Slopes	174 kb	70 kb
Griffith/Murrumbidgee Irrigation Area	167 kb	69 kb

Legend

YES	Available for wireless microphone use.
LIKELY	This frequency is likely to be available for wireless microphone use. However, it is possible that you may receive interference from distant television and radio services in some areas. Seek advice from your supplier to determine whether this frequency is suitable for your needs.
POSSIBLE	This frequency is possibly available for wireless microphone use. However, many locations will be prone to receiving interference from television and radio services or causing interference especially when using the wireless microphone outdoors. Seek advice from your supplier to determine whether this frequency is suitable for your needs.
NO	Not available for wireless microphone use.

Available spectrum for wireless microphones from 1 January 2015

Location	Band	VHF		UHF					
	TV channel	6, 7, 8, 10, 11, 12	27	28, 29, 30, 31, 32, 33	34, 35, 36, 37, 38, 39	40, 41, 42, 43, 44, 45	46, 47, 48,	49, 50, 51
	Frequency (MHz)	174–195	520–526	526–568	568–610	610–652	652–673	673–694
		209–230	(see Note 3)					
Sydney		NO	NO	POSSIBLE	NO	LIKELY	LIKELY	
Central Coast		NO	LIKELY	NO	NO	NO		
Surrounding areas								
Agnes Banks		NO	NO	NO	NO	YES		
Appin		NO	NO	NO	NO	NO	NO	
Bargo		NO	NO	NO	NO	NO	NO	
Belimbla Park		NO	NO	NO	NO	NO	NO	
Blackheath		NO	NO	NO	NO	YES		
Bowen Mountain		NO	NO	NO	YES			
Brooklyn		NO	NO	YES	YES	NO	NO	
Bundanoon		NO	NO	NO	NO	YES		
Buxton		NO	NO	NO	NO	YES		
Catherine Field		NO	NO	NO	NO	YES		
Cobbitty		NO	NO	NO	NO	YES		
Coorumbin		NO	NO	NO	NO	YES		
Cowan		NO	NO	YES	YES			
Dangar Island		NO	NO	YES	YES			
Douglas Park		NO	NO	NO	NO	NO	NO	
Freemans Reach		NO	NO	NO	NO	NO	NO	
Galston		NO	NO	NO	NO	YES		
Glenorie		NO	NO	NO	NO	YES		
Glossodia		NO	NO	NO	NO			
Grasmere		NO	NO	NO	NO			
Headcorn		NO	NO	NO	NO	NO	POSSIBLE	
Jilliby		NO	NO	NO	NO	NO	NO	
Kelsonville		NO	NO	NO	NO	NO	POSSIBLE	
Kirkham		NO	NO	NO	NO			
Kurmond		NO	NO	NO	NO			
Kurrajong		NO	NO	NO	NO			
Kurrajong Heights		NO	NO	NO	NO			
Lawson		NO	NO	NO	NO	NO	POSSIBLE	
Leeuwpton		NO	NO	NO	NO	YES	YES	

This spreadsheet on the ACMA website lists towns and suburbs throughout Australia with the six UHF and one VHF bands listed with a YES/LIKELY/POSSIBLE/NO indication of whether wireless mics in those bands can be used in that area. As you can see from the generally yellow ('NO') boxes in this chart, in many areas you're going to be pretty limited for choice. The URL for this site is a mile long but you can access it by Googling "ACMA Fact sheets and FAQs" – it's the first entry – click on that, then click on the town or suburb you want.

the NSW coast, and their frequencies. With the exception of the 520-526MHz soon-to-be-packed-out band, you will probably find that there are many areas where finding an unused frequency is almost impossible; you need to choose the best of a bad situation. Country areas aren't quite so packed.

Our experience

We mentioned earlier that we have considerable experience in audio/PA and, by extension, wireless microphones. Over the past 12 months or so we've talked to literally scores of 'average' (ie, not professional) wireless microphone users and with just one exception, there was complete ignorance about the forthcoming changes.

These users were in the main sporting clubs, reception venues and the like and they simply hadn't heard ANYTHING about their equipment being outlawed.

The reaction was even more disturbing: they couldn't give a damn. "Let them catch me" was a typical response. "I'll go on using it until someone tells me to stop" was common. Or the old shrug of the shoulders and "so what?" expression.

That one exception was a sporting organisation who does use a professional technician to supply and maintain their equipment. They'd just upgraded their whole PA system and part of that deal was new 500MHz wireless microphones, because their supplier knew the new requirements.

But the rest? They can be assured that there will one day be a knock on the door, not necessarily from ACMA but from one of the telcos who's just forked out a LOT of money (Billion$!) for the right to use clean spectrum.

As soon as there is any report of interference by their customers, you can bet your bottom dollar (or billions of dollars!) that they will 'search and destroy' all offenders.

So what to buy?

If you're in the market for a wireless microphone (and if you currently use one, that description probably fits you!) there are a couple of things you should look for:

(a) Naturally, you must choose a wireless microphone in that 520-694MHz band. Don't be tempted by descriptions which claim "approved frequencies" or some such if they aren't in that band. They aren't (approved, that is).

(b) Take careful note of the digital TV frequencies being used in your area – and surrounds. Choose a microphone well away from these frequencies.

(c) While theoretically within the TV band, 520-526MHz is currently unused by any TV channel, anywhere in Australia – so a wireless microphone in that frequency range should remain usable anywhere for at least the foreseeable future.

However, there is no guarantee that this band (TV channel 27) will not be taken up somewhere down the track (after all, they took 694-820MHz away!). And as we mentioned earlier, 520-526MHz is likely to become VERY crowded!

(d) If at all possible, choose a wireless microphone that is 'frequency agile' – that is, you can adjust its operating frequency (usually by pushing buttons). Of course, the receiver will need to have the same feature but if they are sold as a system, that's pretty much taken for granted.

The better wireless microphone systems are almost always frequency-agile but it is often found on cheaper ones as well.

(e) Buy from a reputable source and get a money-back guarantee in case you find it can't be used in your area. That's why it is usually preferable to buy from a bricks-and-mortar store than online, even if you do have to pay a little more.

If you do buy online, choose an Australian supplier who you can track down!

Need more info?

There's a lot more information available on the ACMA website which, if you're interested in wireless mics and/or digital TV, makes interesting reading. It's just a pity that so few people know anything about this resource.

So to summarise: if you have a wireless microphone which works in the 694-820MHz band, you need to buy a new one before December 31 this year and preferably one which is 'frequency-agile' so it can be set to suit your location. Don't assume that you won't be affected. At the worst, you could be fined or digital TV interference could simply blot your microphone out. Depending on the situation, that could be even more embarrassing.

Operating Wireless Microphones in UHF TV Areas: even now there are traps for young players!

Over the past few months, I've been using the PA system referred to in the main article, the one which had the new approved wireless microphones, for outdoor sports. It was being used in a 'portable' mode; that is, the PA was erected at a specific venue for one or two days, then packed away.

The first few times I used it, up and down the NSW coast, it performed flawlessly. The wireless microphones had more than enough range (I estimated 250m line of sight) but the most recent occasion, in the Illawarra region of NSW, the range was woeful – perhaps 10m or so but very intermittent. So what had changed?

The first thing I did was ensure that the wireless mic receiver antennas weren't being shielded – that's a common problem. Even damp or wet bricks in a building wall can chop the range way down. I elevated the receiver so it had perfect line-of-sight through a window. Nope – no change!

Batteries? Most microphones these days operate on one or two "AA" cells, which obviously don't last forever. I replaced the batteries and . . . scratch that one!

Speaking of scratching, I was: my head, that is. I raised my eyes to the heavens for inspiration . . . and the answer stared back at me! I was in the northern suburbs of Wollongong and I was looking straight up at the TV transmitters on Broker's Nose, a prominent point on the Illawarra escarpment which was probably no more than 3-4km away as the crow flies.

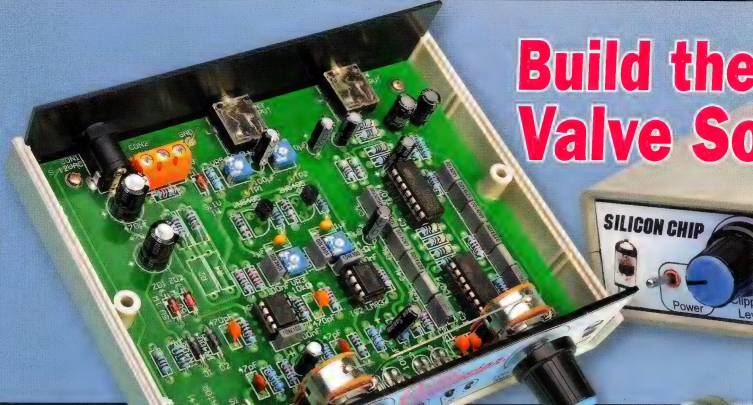
"Could it be TV Interference . . ." There was no indication of any interference on the PA system but I wondered if the strong UHF TV signal was simply swamping the wireless mic receiver.

Fortunately, the wireless mics were frequency agile, so it was easy enough to prove, especially with a two mic/two receiver system for an A:B comparison. I simply moved one of the mics and its receiver to a frequency as far away as I could from where it currently was, and bingo! The range suddenly increased to what I was accustomed to while the other mic/receiver range stayed stubbornly at about 10m!

I adjusted the second mic/receiver pair to another far-distant frequency and was in business immediately.

No, I don't know what frequency I adjusted it to; at the time, I didn't care – because it worked! I didn't have any TV channel listing with me nor did I have 'net access. I also knew I wasn't *causing* any TV interference – there was a TV on in the same room showing the World Cup! I might have been lucky but with an event about to commence, that wasn't my first concern. . .SC

Build the Valve So



Well, we know that there are lots of valve enthusiasts out there who believe that valves are just better; much more musical and pleasant to listen to than those sterile solid-state circuits with oodles of negative feedback and vanishingly small harmonic distortion. Of course, valve amplifiers do have drawbacks, like heat and fragility, but what if you could get 'valve sound' from a solid-state state amplifier? Well now you can, with our Nirvana Valve Sound Simulator.

IT'S BEEN completely against the grain but we have now designed a solid-state circuit which deliberately distorts. Our Publisher, Leo Simpson, has had to be hand-cuffed, blind-folded, muzzled and otherwise restrained from doing what he normally does – driving us towards perfection. Now we have taken another 'path' to produce the 'desirable and musical' effects of valve amplifier circuitry.

OK, OK, we know that if you want genuine, true 'valve sound', the only recourse is to use a valve amplifier. But we are presenting another way to musical nirvana which musicians commonly follow; using a solid-state amplifier with in-built valve circuitry simulation. This way, it's the valve sound you have without using valves.

Our Nirvana Valve Sound Simulator can be connected in series with any solid-state mono or stereo amplifier. It can be used by musicians or in the home for normal music listening. It lets you hear what valve sound is all about so you don't have to go to the expense of replacing a perfectly good solid-state amplifier with a valve amplifier.

What does it do?

When a valve amplifier (sometimes called a tube amplifier) is compared objectively with a modern solid-state amplifier, the results can be somewhat uncomplimentary. The valve amplifier will typically have much higher distortion, more noise, more hum and certainly a less than straight-line frequency response when driving real loudspeakers. But the sum total of those effects is what valve amplifier enthusiasts want: a mellower, softer and (it's claimed) more 'musical' sound.

Our Nirvana Valve Sound Simulator does not add noise and hum but it will produce the same effects on the signal as a valve amplifier: softer symmetrical

or asymmetrical clipping at the point of overload, mainly even-order harmonic distortion similar to the effects of a single pentode valve stage and a frequency response similar to that of a good quality class-AB valve amplifier with transformer coupling to the loudspeaker.

We simulate the pentode valve stage effect by using a FET source-follower in the signal path. The soft clipping effect is achieved in the same FET source-follower stage and it is fully adjustable for degree, asymmetry etc.

We also need to simulate the effect of a valve amplifier's output impedance on the frequency response of a typical loudspeaker. This is where solid-state amplifiers have a big advantage over valve amplifiers. Well-designed solid-state amplifiers usually have an output impedance which is less than one-sixtieth of the nominal impedance of a loudspeaker, ie, something less than 150 milliohms. By contrast, a valve amplifier will typically have an output impedance of about 2Ω, depending on how much negative feedback is applied from the output terminals back to the earlier stages.

The relatively high output impedance of the valve amplifier has two effects when driving loudspeakers. The first effect is a much lower 'damping factor' which is the ratio of nominal loudspeaker impedance to the amplifier's output impedance. For a solid-state amplifier, we expect to see damping factors of 60 or more and that means that the amplifier has very tight control over the movement of the loudspeaker cone. This leads to less 'boomy' bass and lower distortion of bass frequencies.

An equally important advantage of a very low output impedance is a much more linear frequency response from all loudspeakers. This is because loudspeakers do not have a constant impedance, but one that varies widely with frequency. So ideally, a loudspeaker should be driven from a voltage source and that means having a low output impedance amplifier.

With the much higher output impedance of a valve amplifier, the considerable variations in a loudspeaker's impedance over the frequency range means that the overall response will be much 'bumpier' or less smooth. Say, for example, a valve amplifier has an output impedance of 2 ohms and the loudspeaker has a nominal output impedance of 8 ohms. That means that 25% of the drive signal will be lost within the amplifier itself.

But the effect is much worse because the loudspeaker's impedance varies from less than 6 ohms to more than 30 ohms.

Fig.1 shows a bass reflex loudspeaker impedance curve. Typically, these have a double hump at low frequencies, may rise to a second broad peak at the mid-frequencies (depending on the effect of the crossover network) and then rise again at the high end, due to the inductance of the tweeter. By contrast, loudspeakers in sealed cabinets have only one peak at the low frequency end.

Any increase in impedance above the nominal value (eg, 8 ohms) at a particular frequency will result in a boost to the loudspeaker's response, while a reduction will result in a drop in the response – see Fig.3. This diagram depicts the effect on the frequency response of four loudspeaker systems,

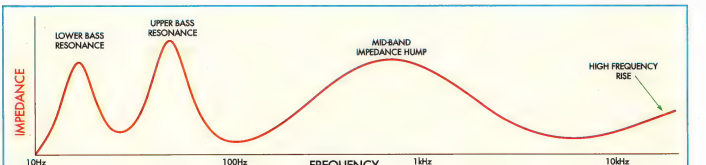
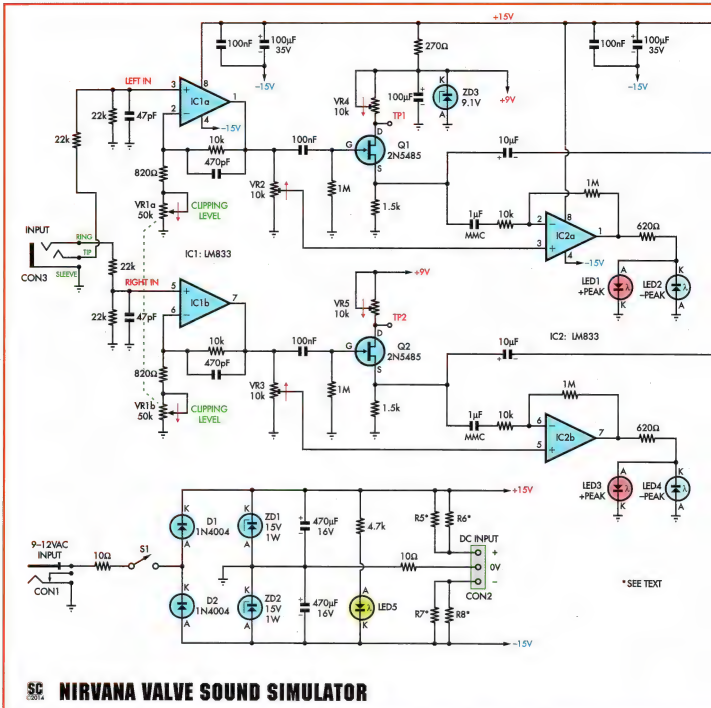


Fig.1: a typical bass reflex loudspeaker impedance curve. As shown, there's a double hump at low frequencies, with the impedance then rising to a broad peak at the mid-frequencies (depending on the effect of the crossover network) and then rising again at the high end, due to the inductance of the tweeter.



NIRVANA VALVE SOUND SIMULATOR

previously published in SILICON CHIP, when driven by an amplifier with an output impedance of 4 ohms.

As you can see, the main areas of boosting occur at the two bass resonances and at the mid-band impedance hump. For example, with the JV100 loudspeaker depicted at the top of Fig.3, the boost is as much as +3.9dB. Similarly, there is a broad boost to the response of more than +3dB from around 500Hz to 1.5kHz and a smaller boost to the tweeter at the high-frequency end.

By contrast, if the same loudspeaker is driven by a solid-state amplifier with a typical output impedance of less than 150 milliohms, there is no boost or cut, as it should be!

The Nirvana simulates these loudspeaker frequency deviations with a number of individually adjustable filters which are varied by the "Loudspeaker Response" control. The selection of a particular loudspeaker for simulation requires choosing a particular set of component values, to be discussed later in this article.

The other control on the front panel of the Nirvana Valve Sound Simulator is for 'Clipping Level'.

If you want to delve more into valve sound, here are some interesting sites:
(1) http://spectrum.ieee.org/consumer-electronics/audiovideo/the-cool-sound-of-tubes
(2) http://spectrum.ieee.org/consumer-electronics/audiovideo/the-cool-sound-of-tubes/distortion

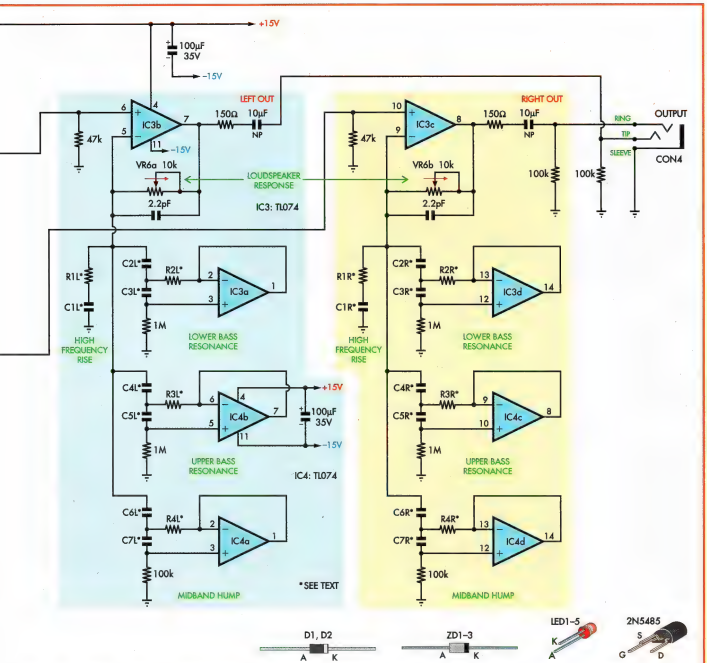


Fig.2: the complete circuit of the Nirvana Valve Sound Simulator. The input signals from CON3 are amplified by IC1, then distorted and clipped by JFETs Q1 & Q2. IC2 provides an indication of clipping symmetry while IC3 & IC4 act as parametric equalisers to adjust the frequency response to match that of a typical valve amplifier driving loudspeakers.

(3) http://en.wikipedia.org/wiki/Tube_sound

In use, the Nirvana Valve Sound Simulator connects between the preamplifier outputs and the power amplifier inputs of a solid-state amplifier. In amplifiers with a tape loop you can use this facility, while for a musician's (eg, guitar) amplifier, it would be connected into the effects loop.

As shown in the photos, the unit is housed in a compact case and can be powered from an AC plugpack. Alternatively, balanced DC supply rails could be obtained from existing equipment. The socket for the AC supply is accessed from the rear, as are the 3.5mm stereo input and output sockets.

Circuit details

Refer now to Fig.2 for the circuit details. Each channel uses six op amps (all in four ICs) and a JFET, and both channels are identical.

The input signal is applied via CON3, a stereo 3.5mm jack socket. If only a mono signal is required, then a mono jack plug can be used to apply signal to the left channel only. This will connect the ring terminal to ground and so prevent signal in the right channel.

The following circuit description is for the left channel signal path. As shown, signal is applied via the tip connection of CON3 and is reduced by a factor of two, using two 22kΩ resistors, so that line-level signals will not necessarily cause clipping in the

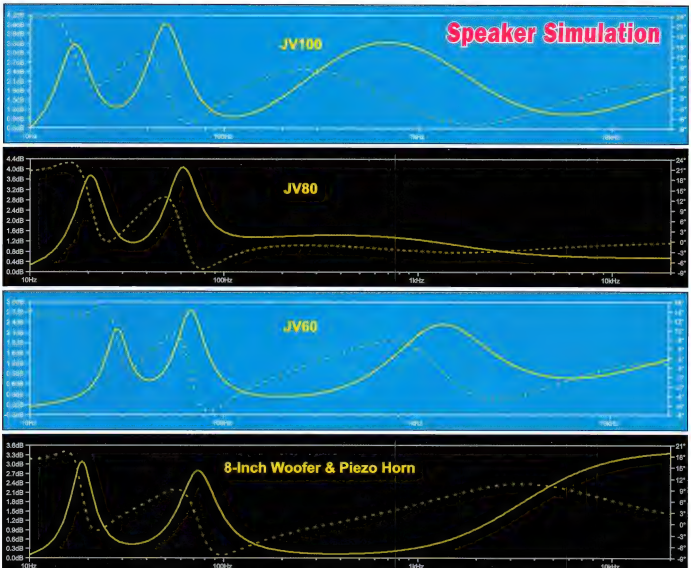


Fig.3: these curves simulate the wide deviations from a flat frequency response for four loudspeakers previously published in SILICON CHIP, caused by the interaction of the varying loudspeaker impedance with the typical 4-ohm output impedance of a valve amplifier. The amount of boost can be seen on the left-hand vertical axis (in dB) while the deviation in phase is shown in the dotted curves and the corresponding right-hand vertical axis (in degrees). These same effects can simulated with the Loudspeaker Response control of the Nirvana Valve Sound Simulator.

following JFET stage if op amp IC1a is set for minimum gain.

IC1a's gain can be varied between 1.2 and 13 by potentiometer VR1a which sets the signal clipping level in the JFET stage. When VR1a is set for minimum gain, the input signal needs to reach 1.66V RMS before clipping occurs and when VR1a is set for maximum gain, the input signal only needs to reach 109mV RMS before clipping.

Following IC1a is the JFET amplifier stage, Q1. This is configured as a source follower (similar to a bipolar transistor emitter-follower or a valve cathode-follower). The JFET produces harmonic distortion similar to that in pentode valve stages (predominantly even harmonics) and it also produces soft signal clipping when overloaded.

The signal from IC1a is fed to the Q1's gate via a 100nF capacitor, while the signal output is taken from Q1's source. Trimpot VR4 adjusts Q1's operating current and this varies the symmetry of clipping, ie, whether the

Main Features

- Simulates the frequency response of a valve amplifier when driving loudspeakers
- Provides mainly even-ordered harmonic distortion, ie, second, fourth, sixth etc
- Input level control sets distortion threshold and clipping
- Soft clipping on overload
- Clipping indicators for positive and negative signal excursions
- Clipping symmetry can be adjusted
- One of four different loudspeaker responses can be used or design your own
- Can run from a 9-12VAC supply (eg, a plugpack) or a ±12VDC to ±45V DC dual supply (eg, from existing equipment)

signal clips symmetrically or whether it clips the positive or negative signal swings more severely.

IC2a drives the positive and negative clipping indicators. It compares the input and output signals of Q1. When the signals differ, such as when Q1 is clipping, the output of IC2a swings high or low to drive LED1 (positive clipping) or LED2 (negative clipping). For this indication to be accurate, IC2a's gain needs to be carefully adjusted to be equal to the gain of Q1, using trimpot VR2 (or VR3 in the right channel).

Loudspeaker simulation

The output signal from Q1 is then fed to the loudspeaker simulator section which comprises op amps IC3b, IC3a, IC4b & IC4a (the equivalent functions in the right channel are provided by IC3c, IC3d, IC4c & IC4d).

IC3b can be regarded as the main op amp and its feedback network is modified by op amps IC3a, IC4a & IC4b which can each be regarded as single-frequency equalisers, much like those used in gyrator-based graphic equalisers. The difference is that we have no slider controls to vary the individual equalisers. The maximum gain at high frequencies is set by 'high-frequency rise' components R1L and C1L and the overall gain is set by VR6a, the Loudspeaker Response control.

IC3a is the equaliser providing the simulated lower frequency impedance peak in a bass-reflex loudspeaker system. IC4b adds the upper bass peak for bass-reflex systems and the main peak in sealed systems. In the latter case, IC3a is effectively disabled and has no effect on the overall frequency response.

Finally, IC4a provides a mid-band impedance hump that may be present with some speaker systems.

So each of the three equalisers boosts a defined frequency band about a certain centre frequency.

By selecting the values of the capacitors and resistors, we can set the required tuning frequency and shape of the boost. We have designed the speaker impedance simulation circuitry using LTSpice (see www.linear.com/designtools/software/). This SPICE simulation program from Linear Technology can be used with Windows or Mac operating systems.

The circuit file for this loudspeaker simulation (Valve Simulator.asc) is available on our website. You can change the values and set the loudspeaker simulation curve yourself if you wish. Otherwise, we have a table that produces impedance curves for some typical loudspeakers.

Parts List

1 double-sided PCB, code 01106141, 129.5 x 100mm
1 front-panel artwork, 132 x 27mm OR 1 front-panel PCB, code 01106142
1 rear panel artwork, 132 x 27mm
1 ABS instrument case, 140 x 110 x 35mm (Jaycar HB-5970, Altronics H 0472)
1 9-12V 50mA AC plugpack (optional, see text)
1 PCB-mount DC socket (CON1)
1 3-way PCB-mount screw terminal block, 5.08mm pitch (CON2)
2 3.5mm PCB-mount stereo jack sockets (CON3,CON4)
1 SPDT PCB-mount toggle switch (S1) (Altronics S 1421)
1 16mm dual-gang 50kΩ linear potentiometer (VR1)
1 16mm dual-gang 10kΩ linear potentiometer (VR6)
4 10kΩ horizontal trimpots (VR2-VR5)
2 knobs to suit potentiometers
2 DIL8 IC sockets (optional)
2 DIL14 IC sockets (optional)
4 No.4 x 6mm self-tapping screws
4 PC stakes (GND,GND,TP1,TP2)
1 100mm length of 0.7mm tinned copper wire

Semiconductors

2 LM833 op amps (IC1,IC2)
2 TL074 quad op amps (IC3,IC4)
2 2N5485 JFETs (Q1,Q2)
2 3mm high-intensity red LEDs (LED1,LED3)
2 3mm high-intensity blue LEDs (LED2,LED4)
1 3mm high-intensity green LED (LED5)
2 15V 1W zener diodes (ZD1,ZD2)
1 9.1V 1W zener diode (ZD3)
2 1N4004 1A diodes (D1,D2)

Capacitors

2 470µF 16V PC electrolytic
5 100µF 35-63V PC electrolytic
2 10µF 16V PC electrolytic
2 10µF 16V NP PC electrolytic
2 1µF monolithic ceramic
4 100nF MKT
2 470pF ceramic
2 47pF ceramic
2 2.2pF ceramic

Selected capacitors

JV100 simulation: 2 x 330nF, 2 x 150nF, 2 x 47nF, 2 x 22nF, 2 x 6.8nF & 2 x 1nF MKT, plus 2 x 470pF ceramic
JV80 simulation: 2 x 270nF, 2 x 100nF, 2 x 56nF, 2 x 22nF, 2 x 6.8nF & 2 x 1nF MKT
JV60 simulation: 2 x 120nF, 2 x 82nF, 2 x 22nF, 2 x 12nF, 2 x 6.8nF & 2 x 1nF MKT, plus 2 x 470pF ceramic
8-inch woofer with piezo horn simulation: 2 x 270nF, 2 x 100nF, 2 x 33nF & 4 x 4.7nF MKT

Resistors (0.25W, 1%)

8 1MΩ	2 1.5kΩ
4 100kΩ	2 820Ω
2 47kΩ	2 620Ω
4 22kΩ	1 270Ω
4 10kΩ	2 150Ω
1 4.7kΩ	2 10Ω

Selected resistors

JV100 simulation: 2 x 22kΩ, 4 x 12kΩ, 2 x 10kΩ
JV80 simulation: 2 x 33kΩ, 4 x 10kΩ
JV60 simulation: 2 x 22kΩ, 4 x 12kΩ, 2 x 10kΩ
8-inch woofer with piezo horn simulation: 2 x 10kΩ, 4 x 8.2kΩ

Power supply resistors

R5-R8: see text & Table 1

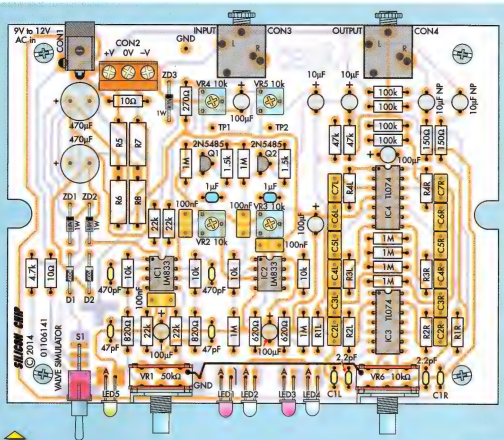
Power supply

Power for the circuit can come from an AC plugpack (9-12V) rated at 50mA or more. Alternatively, positive and negative DC supply rails from existing equipment can be used. In the latter case, power is applied via CON2.

Resistors R5, R6, R7 & R8 are used when the external supply is 15V or more. They provide the voltage drop for 15V zener diodes ZD1 and ZD2. Table 1 on the following page shows the resistor values required for various supply voltages.

Construction

The construction is straightforward with all the parts mounted on a PCB coded 01106141 and measuring 129.5 x 100mm. This is housed in a small instrument case measuring 140 x 110 x 35mm (W x D x H).



The PCB is fastened into the case using four self-tapping screws which go into integral corner pillars.

Fig.4: follow this parts layout diagram to build the PCB. Resistors R1-R4 and capacitors C1-C7 in the filter networks are selected from Table 2, while the power supply resistors (R5-R8) are selected from Table 1 (see text).

Table 1. Dropping Resistors For External Dual Supply Rails

Supply Voltage	R5	R6	R7	R8
±45VDC	2.7kΩ 1W	2.7kΩ 1W	2.7kΩ 1W	2.7kΩ 1W
±40VDC	2.2kΩ 1W	2.2kΩ 1W	2.2kΩ 1W	2.2kΩ 1W
±35VDC	1.5kΩ 1W	1.5kΩ 1W	1.5kΩ 1W	1.5kΩ 1W
±30VDC	620Ω 1W	–	620Ω 1W	–
±25VDC	390Ω 1W	–	390Ω 1W	–
±20VDC	220Ω 1/2W	–	220Ω 1/2W	–
±15VDC	10Ω 1/2W	–	10Ω 1/2W	–
±12VDC	10Ω 1/2W	–	10Ω 1/2W	–

Note: a dash (–) means that no component is installed.

Before installing any of the parts, you need to use Table 2 to select the required values for resistors R1-R4 and capacitors C1-C7 to simulate a particular speaker. These values depend on the speaker load that is being simulated, as explained earlier.

Basically, Table 2 shows the values required to simulate various loudspeaker loads. In other words, you can simulate the sound of a valve amplifier driving one of these types of speakers.

If you don't have a preference, we suggest using the JV80 values. Alternatively, you can determine your own component values based on LTSpice

Table 2: R & C Values For Vented, Sealed & Piezo Horn Loudspeakers

Loudspeaker	VR6 Setting	HF Rise		First Impedance Peak			Second Impedance Peak			Midband Hump		
		C1	R1	C2*	C3*	R2*	C4	C5	R3	C6	C7	R4
JV100 (8-ohm)	5.6kΩ	470pF	22kΩ	330nF	22nF	12kΩ	150nF	6.8nF	10kΩ	47nF	1nF	12kΩ
JV80 (8-ohm)	5.6kΩ	–	–	270nF	22nF	10kΩ	100nF	6.8nF	10kΩ	56nF	1nF	33kΩ
JV60 (4-ohm)	3.9kΩ	470pF	22kΩ	330nF	22nF	12kΩ	82nF	6.8nF	10kΩ	12nF	1nF	12kΩ
8-inch speakers, with piezo horn (8-ohm)	3.9kΩ	4.7nF	8.2kΩ	270nF	33nF	8.2kΩ	100nF	4.7nF	10kΩ	–	–	–

Note 1: R & C numbers show an 'L' suffix for the left channel components and an 'R' suffix for the right channel components on the circuit and PCB layout. Note 2: * denotes no component for a sealed enclosure. Note 3: VR6 setting shown is for 4Ω output impedance amplifiers. VR6 is set to a lower resistance for lower output impedance. Note 4: a dash (–) means that no component is installed.

simulation, as explained earlier.

You also need to decide on the power supply that you will be using and select resistors R5-R8 from Table 1 if using an external split DC supply (ie, one with positive and negative supply rails). This could come from a power amplifier or preamplifier, for example.

Alternatively, resistors R5-R8 are not required if using an external 9-12VAC plugpack supply.

Fig.4 shows the parts layout on the PCB. Begin the assembly by installing the resistors. Table 3 shows the resistor colour codes but you should also check each one using a DMM before mounting it in place.

Follow with the IC sockets, diodes D1 & D2, zener diodes ZD1-ZD3 and trimpots VR2-VR5. Take care to ensure that the diodes and zener diodes are orientated correctly and note that the IC sockets all face in the same direction (ie, pin 1 at top left).

The capacitors are next on the list. Table 4 shows the codes used on the smaller ceramic and MKT types. Be sure to orientate the polarised electrolytic types correctly and note that the two 10µF electrolytics at top right are non-polarised (NP).

Switch S1 and power socket CON1 are necessary only if using the AC plugpack for the supply. Conversely, 3-way screw terminal block CON2 is necessary only if you are using an external split DC supply.

Now for the two potentiometers (VR1 & VR6). Before fitting them, cut their shafts to suit the knobs using a hacksaw and clean up the ends with a file. It's also necessary to file away a small area of the passivation layer at the top of each pot body, to allow an earth wire to be later soldered in place (see Fig.4).

The pots are then fitted to the PCB, noting that VR1 is 50kΩ and VR6 is 10kΩ. Push them all the way down onto the PCB before soldering their pins.

The two 3.5mm jack sockets (CON3 & CON4) can go in next, followed by PC stakes for TP1 & TP2 and at the two GND positions (one to the right of VR1 and one to the left of CON3).

Installing the LEDs

The five LEDs are installed with their leads bent down through 90°, so that they later protrude through matching holes in the front panel. First, check that the anode (longer) lead is to the left (lens facing towards you), then bend both leads down through 90° exactly 8mm from the rear of the plastic lens. This is best done by folding them over a cardboard strip cut to 8mm wide.

Once that's done, install each LED so that its horizontal leads are exactly 4mm above the PCB. In practice, it's just a matter of pushing each LED down onto a 4mm-thick spacer (eg, a cardboard strip) before soldering its leads. Use a green LED for LED5, red

Table 4: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u0	105
100nF	0.1µF	100n	104
470pF	NA	470p	471
47pF	NA	47p	47
2.2pF	NA	2p2	2.2

Table 3: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	8	1MΩ	brown black green brown	brown black black yellow brown
❑	4	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	4	22kΩ	red red orange brown	red red black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	1.5kΩ	brown green red brown	brown green black brown brown
❑	2	820Ω	grey red brown brown	grey red black black brown
❑	2	620Ω	blue red brown brown	blue red black black brown
❑	1	270Ω	red violet brown brown	red violet black black brown
❑	2	150Ω	brown green brown brown	brown green black black brown
❑	2	10Ω	brown black black brown	brown black black gold brown

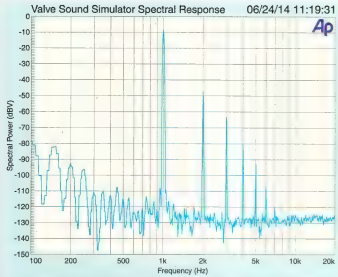


Fig.5: spectrum analysis of the output signal (1kHz input), showing strong second harmonic distortion along with third, fourth, fifth and sixth harmonics at lower levels.

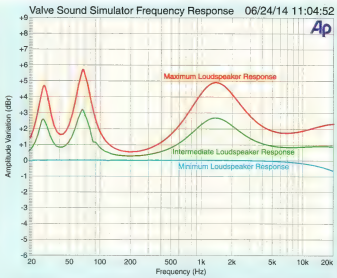


Fig.6: this graph shows the frequency response of the unit when set to simulate driving JV60s, with the Loudspeaker Response knob in three different positions.

LEDs for LEDs1&3 and blue LEDs for LEDs2&4.

The PCB assembly can now be completed by earthing the pot bodies to the GND PC stake next to VR1. That's done using a length of 0.7mm-diameter tinned copper wire (see Fig.4 and photos). You can straighten the tinned copper wire by clamping one end in a vice and then stretching it slightly by pulling on the other end with pliers. It can then be bent to shape so that it contacts the GND stake and soldered.

Final assembly

Before installing the PCB assembly in the case, you have to drill a number of holes for the front and rear panels. The accompanying panel artworks (Fig.7) can be copied and used as drilling templates or you can download them (in PDF format) from the SILICON CHIP website and print them out.

On the front panel, you will need to drill (and ream) a 5mm hole for switch S1, 3mm holes for LEDs1-5 and 7mm holes for the pot shafts. The two stereo jack sockets on the rear panel require 6mm holes, while the DC power socket requires a 6.5mm access hole.

Once that's done, print the artworks from the website onto photo paper and attach them to the panels using silicone sealant. The holes can then be cut out with a sharp hobby knife.

Alternatively, you can purchase a PCB-based front panel (blue with white labels) with pre-drilled holes from the SILICON CHIP Partshop.

After that, it's just a matter of fitting the panels to the PCB, sliding the assembly into the case and securing the PCB to the four corner mounting pillars using No.4 self-tapping screws. The assembly can then be completed by pushing the knobs onto the pot shafts. Reposition the end pointers of the knobs if necessary, so that they correctly point to the fully anti-clockwise and fully clockwise positions.

Testing

If you haven't already done so, insert the four ICs into their sockets, taking care to orientate them correctly. Next, apply power and check that the power LED lights. If that checks out, check the supply voltage between pins 8 & 4 of both IC1 and IC2 and between pins 4 & 11 of IC3 and IC4. This should be around 30V DC if you are applying 12VAC via CON1. Alternatively, you can apply ±12V DC or more via 3-way screw terminal block CON2.

Note that you will only get around 25V (ie, ±12.5V) if using a 9VAC supply. Regardless, there should be about 9.1V across ZD3.

Assuming these supply voltages are

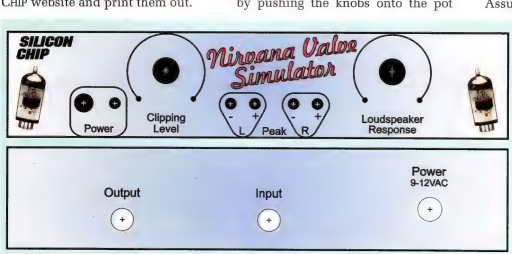


Fig.7: these two artworks can be copied and used as drilling templates for the front & rear panels. They can also be downloaded as a PDF file from the SILICON CHIP website.

all correct, follow this step-by-step procedure to adjust the unit:

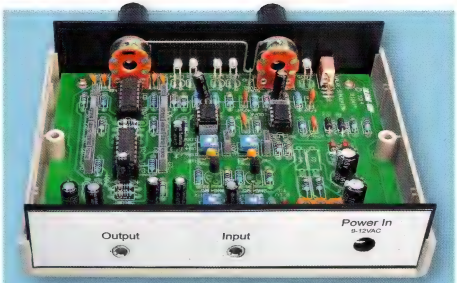
Step 1: connect a DMM set to volts between TP1 and a GND stake and adjust VR4 for a reading of 5.8V. Similarly, adjust VR5 for a reading of 5.8V at TP2. This gives more or less symmetrical clipping for both Q1 and Q2.

Step 2: apply a low-level 1kHz signal to both the left and right inputs and adjust VR2 & VR3 so that the positive and negative peak LEDs in both channels are off. You will find that there's a 'dead spot' in each trimpot's setting range where both LEDs are off. Set each trimpot to the middle of its dead spot.

If the LEDs do not extinguish with this adjustment, try reducing the signal level using VR1 or at the signal generator (note: if you don't have a signal generator, it's easy to find a virtual instrument online).

Step 3: increase the signal level so that the clipping LEDs begin to light. When that happens, readjust trimpots VR4 & VR5 to give symmetrical clipping, so that both the red and blue clipping LEDs light at the same time (ie, for the positive and negative signal excursions).

Finally, note that the input and output sockets can be linked to RCA connectors via adaptor cables (ie, 3.5mm stereo jack plug to RCA). For mono use, a mono 3.5mm jack plug can be used in which case only the left channel will be supplied with signal and the right channel input will be grounded. A mono plug could then also be used for the output since the right channel will not have any output. **SC**



The rear panel carries access holes for the input and output sockets and for the power socket. Note how the metal bodies of the two pots are earthed to the GND stake using a length of tinned copper wire.

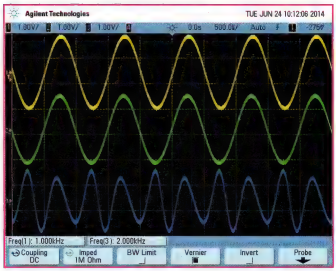


Fig.8: the output of the unit (green) compared to the input (yellow) at 1kHz. The signal level is set below clipping and the distortion residual (blue) is primarily second harmonic. This can be clearly seen as the residual is at twice the fundamental frequency, ie, 2kHz.

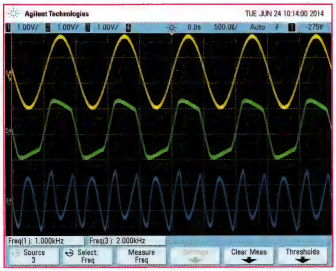


Fig.9: the same traces as in Fig.8 but with more input signal, causing clipping. The effects of soft clipping and the frequency response shaping filter are evident.

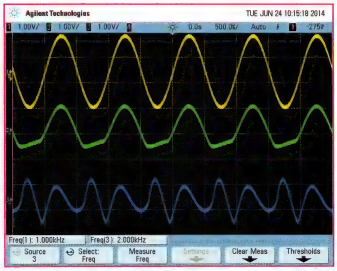
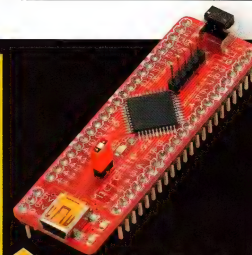


Fig.10: the input signal is still being clipped here but now we have adjusted VR4 & VR5 to give asymmetrical clipping, resulting in a different type of distortion.

The 44-Pin Micromite

Introduced in the May & June 2014 issues of SILICON CHIP, the Micromite is an easily-programmed microcontroller in a 28-pin DIP package. This month, we present its big brother, the 44-Pin Micromite. It has all the features of the original Micromite but with a much more generous 33 I/O pins. Now there's no excuse not to use a Micromite in your biggest project.



The Micromite Module transforms the 44-pin Micromite (which is a surface mount chip) into a plug-in module that's only a little larger than a conventional 44-pin DIL IC. On the top of the module (from bottom left) are the USB connector for the programming console, a jumper for selecting the power source, a green power LED, the Micromite chip, a programming header (if you ever need to upgrade the version of MMBasic) and a reset button.

By GEOFF GRAHAM

BOASTING A LARGE amount of memory, 19 I/O pins and many other features, our original Micromite was based on a low-cost 28-pin microcontroller loaded with a fully-featured BASIC language interpreter called MMBasic.

It's been an instant hit with readers but its one drawback was the limited number of I/O pins. For example, if your project used a keypad and an LCD, you immediately lost 13 pins just supporting those two devices. This left you with only six spare I/O pins for other duties.

This is why we have ported MMBasic to a 44-pin variant of the same PIC32 microcontroller. This version of the Micromite has 33 I/O pins that can be controlled via MMBasic, so you would still have 20 pins free after implementing a keypad and LCD. And that is plenty for connecting distance sensors, servos, IR remote control and whatever else that you might need to finish your project.

The only possible downside is that the 44-pin chip is a surface-mount package. However that's not a real obstacle as we will show you how to solder it to an adaptor board which can then be easily connected to external devices via header pins. We will also describe how to install the 44-Pin Micromite, a USB interface and a power supply on a single PCB that's only a little larger than a regular 40-pin DIL IC.

Micromite Module: Main Features

- 32-bit microcontroller with on-board BASIC interpreter and 42kB memory for program plus variables
- 33 I/O pins including 13 that are analog capable and 17 that are 5V tolerant
- Small form factor, 68 x 22mm
- I/O pins have a 0.1-inch pitch with 0.7-inch track (similar to a 40-pin DIL package)
- Integrated USB-to-serial bridge for the console
- Integrated 3.3V voltage regulator for the microcontroller and external circuitry
- Power requirement: 5V at 38mA plus the current drawn from the I/O pins

The 44-Pin Micromite has all the features of the original 28-pin variant. This includes 42kB of memory for your program and variables combined, floating point calculations, extensive string handling, multi-dimensional arrays and easy control of I/O. Also, like the 28-pin version, this new version has support for IR remote control, distance measuring sensors, temperature sensors and much more.

We won't repeat the description of the original Micromite here. Instead, if you missed the original articles, it would be well worth ordering the May and June 2014 issues from SILICON CHIP (eg, via the website). Alternatively, you can purchase on-line access to these issues.

The only discernible difference between this version and the 28-pin version is that you now have 33 I/O pins at your beck and call. This includes 13 pins that can be used to measure voltage and 17 pins that are 5V tolerant.

Fig.1 shows the pin-outs of the 44-pin Micromite and the capabilities of each I/O pin. As with the 28-pin version, it would be worth copying and laminating this diagram as you will find yourself referring to it quite

Fig.1: these are the connections to the 44-pin Micromite Module and the functions available on each pin. The pins marked with colour labels are used for power etc and cannot be used for general I/O while the other pins can be used for one or more of the following functions:

- **ANALOG: these pins can be used to measure voltage (AIN).**
- **DIGITAL: can be used for digital I/O such as digital input (DIN), digital output (DOUT) and open collector output (OOUT).**
- **INT: can be used to generate an interrupt (INTH, INTL and INTB).**
- **COUNT: can be used to measure frequency (FIN), period (PIN) or counting (CIN).**
- **5V: these pins can be connected to 5V circuits. All other I/O pins are strictly 3.3V maximum.**
- **COM xxx: these are used for serial communications.**
- **I2C xxx: these are used for I2C communications.**
- **SPI xxx: if SPI is enabled these pins will be used for SPI I/O.**
- **PWM xxx: PWM or SERVO output (see the PWM and SERVO commands).**
- **IR: this can be used to receive signals from an infrared remote control (see the IR command).**
- **WAKEUP: this pin can be used to wake the CPU from a sleep (see the CPU SLEEP command).**

Note: the mnemonics in brackets are the modes used in the SETPIN command.

often when designing with the 44-pin Micromite.

Suitable microcontrollers

There are two 44-pin PIC32 microcontroller versions that will work with the Micromite firmware.

The recommended chip is the PIC32MX150F128D-50I/PT which is rated at a top clock speed of 50MHz. The alternative is the PIC32MX150F128D-I/PT which is rated at 40MHz. Either chip can be purchased direct from the Microchip Direct website or from the usual distributors (DigiKey, Mouser, element14, RS Components, etc).

The Micromite will start up with its clock speed set to 40MHz but this can be increased to 48MHz under program control. All the 40MHz chips that we have tested worked OK at 48MHz but this isn't guaranteed. Regardless, the slower chip can be an option if you are unable to source the faster chip or you don't need that extra ounce of speed.

The technical details of the 44-pin chip (supply voltage, drive capability, etc) are the same as for the 28-pin chip.

Adaptor board

One way of getting started with the 44-pin Micromite is to solder it to an adaptor board. These take the 44 pins of the chip and distribute them to header pins on a 0.1-inch pitch. From there, you can attach jumper leads for testing or even install the chip as a plug in module into your final circuit.

If you search the Internet for "44 pin TQFP Adaptor" you will find many examples. For example, Futurlec has these adaptors (Part Code: 44PINTQFP) for $A1.26 each. We'll provide some hints on soldering the chip to this adaptor board later – it's not as daunting as you may believe.

If you purchase a blank chip, it can be programmed with the MMBasic firmware using the circuit shown in Fig.2. Note that you need a decoupling capacitor from pin 7 (Vcap) to ground. This should be either a 10µF multilayer ceramic or a 47µF tantalum. Don't leave this capacitor out or substitute an electrolytic because the chip will fail to start or even worse, you could have intermittent issues.

The Micromite Module

Rather than use the adaptor board, a better option is to build our Micromite Module. It's a PCB measuring just 68 x 22mm and includes the Micromite

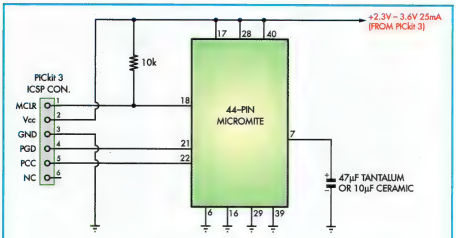


Fig.2: here's how to connect a 44-pin PIC32 microcontroller to a PICkit 3 programmer to load the MMBasic firmware. Once it's wired up, you use MPLAB IPE (free from Microchip) to program the device.

chip, a voltage regulator, a USB interface for the console and all the other parts required to turn the 44-pin Micromite into a complete computer module.

This board uses a similar pin width as a regular 44-pin DIL IC and is only a little longer, so you can treat the completed module as a plug-in component, similar to a large IC. You could plug it into a solderless breadboard for experimenting and then move it to your final circuit which could be on a custom-designed PCB or even built on stripboard.

By the way, the Micromite Module was designed by Phil Boyce in the United Kingdom. Phil was one of our hard-working beta testers for the Micromite firmware and he was so taken with the potential of the 44-pin Micromite that he designed this board to accommodate it. You can purchase blank PCBs from Phil's website (www.micromite.org) or from the SILICON CHIP website.

Fully assembled and tested boards are also available direct from Phil and parts and kits are available from SILICON CHIP (see panel).

Main features

The most useful feature of the Micromite Module is that it incorporates a USB interface for the console, so you don't need a USB-to-serial bridge. You simply plug a USB cable directly into the module and (using either a PC or a Mac) immediately begin to write and edit your BASIC program.

The PCB includes two LEDs to indicate activity on the console – red for received data from the PC to the Micromite Module and green for transmit. These are handy when you are setting up the drivers on the PC, as you can see if your keystrokes actually reach the Micromite.

The module also includes a regulator which accepts either the USB 5V supply or an external 5V supply and regulates it down to 3.3V for the Micromite chip. A second green LED on the top of the board indicates a working 3.3V supply. Both the 5V and 3.3V supplies are also available on several header pins and in the case of the 3.3V supply, can provide up to 100mA for other circuitry.

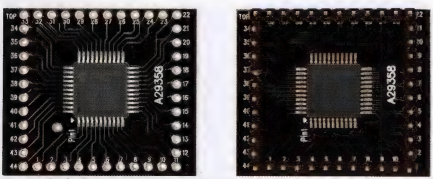
The Micromite chip's connections are all brought out to header pins along the sides of the board. This enables you to build a "short form" version of the board which need only to be populated with the 44-pin Micromite chip and a few decoupling capacitors. This will then act the same as the 44-pin TQFP adaptor described earlier, the difference being that the you can later add the other features of the Micromite Module if you wish.

Because the I/O pin numbers in MMBasic are the same as the actual pin numbers on the chip (and because all the chip's connections are brought out to header pins), the pin numbering scheme is simple to follow. For example, pin 15 in MMBasic is the same as pin 15 on the chip which is also the same as pin 15 on the Micromite Module.

This also means that you can simply follow Fig.1 when you are connecting the Micromite Module into a circuit and writing programs for it.

A jumper on the top of the PCB connects the USB 5V supply to the regulator. This means that if you wish to power the Micromite Module via USB, you should place a jumper on these pins. Alternatively, you can power the module from an external 5V supply (via the header pins along the edge of the board), in which case the jumper must be removed.

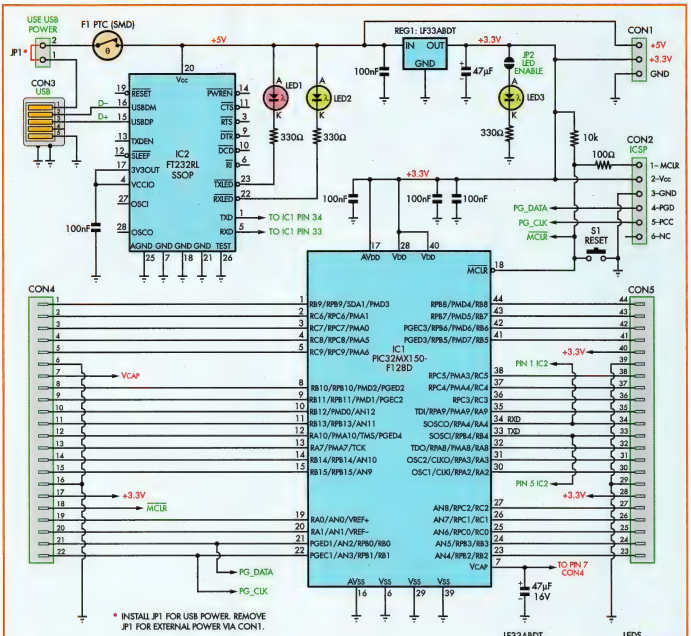
The PCB also includes an ICSP (In-Circuit Serial Programmer) header (CON2) so that you can update the firmware using a programmer such as the PICkit 3. Another useful feature is reset button S1. Pressing this pulls MCLR-bar of IC1 to ground and restarts the Micromite, which is far more convenient than cycling the power (which would also close the USB connection to your computer).



One method of experimenting with the 44-pin Micromite is to mount it on an adaptor board which brings all the chip's connections to header pins with a 0.1-inch pitch. This makes it easy to use the Micromite with a breadboard to develop the final circuit. Adaptor boards can be easily found on the Internet for less than $2.00.

Circuit details

Fig.3 shows the complete circuit



* INSTALL JP1 FOR USB POWER. REMOVE JP1 FOR EXTERNAL POWER VIA CON1.

44-PIN MICROMITE MODULE

Fig.3: the complete circuit for the Micromite Module. IC1 is the 44-pin PIC32 chip programmed with MMBasic, while IC2 (an FT232RL USB-to-serial converter) provides the USB interface. Power can come either from the USB host (JP1 installed) or from an external source via CON1 (JP1 out).

for the Micromite Module. The USB interface is provided by IC2 which is an FT232RL USB-to-serial converter made by Future Technology Devices (FTDI). This chip is used in many USB-to-serial converters and has good driver support for all operating systems. In fact, many operating systems come with the required drivers pre-installed.

As shown, the D+ and D- lines from the USB connector (CON3) are connected to pins 15 & 16 of IC2 respectively. This is then translated to a bi-directional TTL serial interface at pins 1 (TxD, transmit) and 5 (RxD, receive). These are in turn connected to the serial interface of the Micromite chip (IC1), ie, pins 34 & 33 respectively.

The FT232RL also directly drives LED1 (red) and LED2 (green) which indicate activity on the console.

The 5V rail for the FT232RL (IC2) and the 3.3V regulator (REG1) can come from an external source (via CON1) or from the USB host (ie, a PC). In the latter case, jumper JP1 must be installed and F1, which is a PTC resettable fuse, protects the host computer from an accidental short on the 5V output pins.

Note that JP1 must not be installed if an external 5V supply is connected to CON1.

REG1 is a fixed voltage, low-dropout regulator which supplies the Micro-

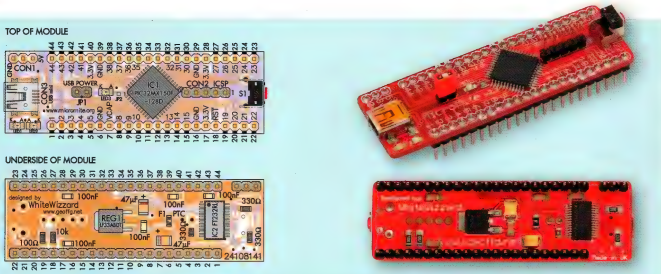


Fig.4: you can purchase a kit of parts and assemble the Micromite Module yourself as shown here. That way you can use the module as just a carrier for the Micromite chip or you can fully populate it with all the parts, including the USB interface and the voltage regulator.

mite chip (IC1) and the green power LED (LED3). This LED can be disabled by leaving the solder pads at JP2 open. This can be important if you are trying to reduce the current consumption and every milliamp is important.

The remaining parts in the circuit are PIC32 microcontroller IC1 (programmed with MMBasic), a few decoupling capacitors, ICSP header CON2 and two single-row 22-pin headers CON4 & CON5.

Building it

Many of the parts used in this project, including the two ICs and the regulator, are surface-mount devices. In addition, parts are mounted on both sides of the PCB. This was done to reduce its size but it is still a relatively painless job to assemble.

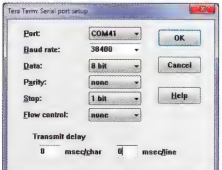


Fig.5: the terminal emulator that you use to connect to the Micromite Module (via USB) should be set to 38400 baud, eight bits data, no parity and one stop bit. This screen grab shows what the set-up dialog in Tera Term should look like with the correct values entered. Note that your port number will almost certainly be different to that shown because it will change with the physical USB port.

Alternatively, a fully-assembled and tested Micromite Module is also available if you don't want to build it yourself (see the accompanying panel: "Where To Buy the Parts").

We have described how surface-mount devices are soldered many times in the past, so we will only give the basics here. You need to start with a good SMD soldering flux (eg, Altronics H1650A or Jaycar NS3036) and a temperature-controlled soldering iron with a small flat tip (not needle-point). A x10 magnifier (preferably a magnifying lamp) is also useful, as is a pair of fine-tipped tweezers.

With SMD soldering you mostly carry the solder to the joint on the iron's tip and because of that, you need a tip with sufficient width (eg, a 0.8mm chisel tip) to hold the solder. You also need to liberally apply the flux to the joint beforehand as any flux in your solder will have boiled away before it reaches the joint.

The Micromite chip has a forgiving 0.8mm pin spacing and is therefore relatively easy to solder. Start by applying plenty of flux to the pads on the PCB, then place the IC on the board and nudge it into position. While doing this make sure that the dot marking pin 1 on the chip matches the corresponding dot on the PCB.

Once it's in place, hold the chip down with tweezers or a matchstick and tack-solder one pin. That done, check that the chip's alignment is still correct then solder the diagonally opposite pin. After that it's just a case of applying more flux to all the pins and soldering them one by one. Don't forget to return to the first pin and resolder it.

The secret is to use only a very small amount of solder on the iron's tip and gently touch it where each pin meets the PCB. Provided you've applied plenty of flux, the solder will magically flow around the pin, making a perfect joint.

If you have too much solder on the iron, the result will be a solder blob joining two or more pins. If that happens, reduce the amount of solder on the iron and carry on. It's then just a matter of going back and removing any excess solder (eg, solder shorts between pins) using solder wick.

Remember, flux is your friend and too much solder your enemy.

If you just want to use the PCB as a carrier for the Micromite chip, you only need to install the chip itself, the 47µF capacitor connected to pin 7 (Vcap) and the three 100nF decoupling capacitors on pins 17, 28 & 40. The SMD capacitors are easy to install: in each case, apply plenty of flux and tack solder one end, then solder the other before returning to the first to complete the job.

Alternatively, if you wish to assemble the full board, you should now move on to IC2, REG1 and the other components. Other than the header pins, which should be left until last, the order of assembly is not important. Note that IC2 (the FT232RL) has a finer pitch than IC1 at 0.65mm but it is still

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Supporting Publication
SILICON CHIP

Australian Technology Park - Sydney 10-11 September 2014
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Parts List: 44-Pin Micromite Module

1 double-sided PCB, code 24108141, 68 x 22mm
1 USB Mini-B SMD socket (5-pin) (Altronics P1308, Rapid 24-0357)
1 PCB-mount SPST tactile switch (right angle, red) (RS Components 745-5182)
2 22-pin single row headers, 0.1-inch
1 5-pin single row header, 0.1-inch
1 3-pin single row header, 0.1-inch
1 2-pin single row header, 0.1-inch

Semiconductors

1 Microchip PIC32MX150F128D-50I/PT microcontroller (SMD: TQFP) programmed with 2410814A.hex (IC1)
1 STMicroelectronics LF33ABDT voltage regulator (SMD:DPAK) (IC2)
1 FTDI FT232RL USB-to-Serial UART (SMD:SSOP-28) (IC3)
1 red LED (SMD:0805) (LED1)
2 green LEDs (SMD:0805) (LED2, LED3)
1 PTC resettable poly-fuse (SMD:1206) (Littelfuse 1206L050YR)

Capacitors

2 47µF 6.3V tantalum, ESR <1Ω (SMD:1210)
5 100nF ceramic (SMD:1206)

Resistors

1 10kΩ (SMD: 1206)
1 330Ω (SMD: 0805)
2 330Ω (SMD: 1206)
1 100Ω (SMD: 1206)

a straightforward soldering job.

Don't forget to short the two pads marked JP2 with a blob of solder if you want power indicator LED3 to operate.

Programming the PIC32

As mentioned, if you have a blank microntroller chip, you will need to program it with the MMBasic firmware. The firmware for the 44-pin chip is different to the 28-pin chip version, so be sure to download the correct file. This is labelled as "44-pin" and can be downloaded from the SILICON CHIP website along with an addendum to the user manual covering the 44-pin chip.

To program the microcontroller, you will need a programmer such as the PICkit 3. This should be connected to the ICSP connector which is on the top of the board. Using MPLAB IPE (part of MPLAB X from Microchip), it only takes a few seconds to load MMBasic onto the chip and turn it into a Micromite. Once that has been done, you will not need to use the programmer again unless you decide to upgrade MMBasic to a newer version at a later date.

Fig.6: when you have connected to the Micromite, this is the message that you will see when the reset button is pressed. It shows that the Micromite is working correctly and you can start thinking of the program that you need to write to bring your project to life.

Getting it going

Using the Micromite Module is simplicity itself. First, decide if you are going to use USB or external power and configure jumper JP1 accordingly (ie, install JP1 for USB power; leave it out for external power). That done, connect the Micromite Module to a USB port on your computer and check that the green power LED lights when power is applied (provided you've shorted the JP2 solder pads).

In most cases, the operating system will already have the correct drivers installed and the module will be recognised immediately. If not, you can download the driver from the FTDI website at http://www.ftdichip.com/Drivers/VCP.htm

With the correct driver installed, the Micromite Module will appear as a "USB Serial Port" in the device listing on your computer. You then need to run a VT100 compatible terminal emulator such as Tera Term (for Windows) and connect to the new communications port created by the Micromite Module.

Now, when you press return on the terminal emulator, you should see a flash from the red LED (LED1, receive data) on the board and a flash from the green LED (LED2, transmit data) as the Micromite responds with the command prompt (ie, >).

If you don't see the red LED flash then something must be wrong with either the FT232RL chip (IC2) or the configuration of your computer. If you get a red flash when you press return but no green flash, the fault probably lies with the Micromite chip (eg, has it been programmed with the correct firmware?).

Once you have both LEDs flashing correctly and the command prompt showing on your terminal emulator, you are ready to go. You can now enter and run your first program on the 44-pin Micromite.

Firmware updates

For firmware updates and handy hints, check the author's website at geoffg.net/terminal.html Firmware updates will also be posted on the SILICON CHIP website at www.siliconchip.com.au

Finally, you should also check out the Back Shed forum at thebackshed.com/forum/forum_topics.asp?FID=16 It has many Maximite and Micromite enthusiasts who will be only too happy to help beginners. SC

Where To Buy The Parts

Various forms of the Micromite Module can be purchased from Phil Boyce's website at www.micromite.org The options include a blank PCB (£3), a stripped-down 44-Pin Micromite Light Module (£10) and a fully-assembled 44-Pin Micromite Module (£23.50). Check his website for details and many other Micromite add-ons.

Alternatively, all the parts (including the PCB and a pre-programmed 44-pin Micromite chip) can be purchased as a kit for $A35 including GST (plus p&p) from the SILICON CHIP Online Shop. The PCB and pre-programmed Micromite chip are also available separately. MMBasic and a User Manual are also available on the SILICON CHIP website (free of charge).

Acknowledgement

The author would like to thank the more than 40 dedicated beta testers who worked for over two months to ensure that the Micromite software is as bug-free as possible.

ONLINE & IN STORE

AUTOMATE AUGUST

Digital Keypad with RFID Access Control

Suitable for an area requiring stricter access control such as a laboratory, warehouse, bank etc. Housed in a sturdy IP65 vandal proof zinc alloy casing.

- Waterproof
- 2000 users
- Backlit keypad
- 12VDC

LA-5353

$99

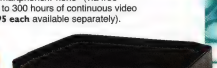
Economy 4 Channel DVR

An affordable 4 channel DVR for home or office surveillance. Connect to a computer network to view video remotely from anywhere in the world using a web browser or Smartphone/iPhone® (via free installed app). Includes 500GB of storage for up to 300 hours of continuous video recording from up to 4 cameras (**QC-3239 $59.95 each** available separately).

- Manual, scheduled or movement activation
- USB/HDMI connection
- Size: 300(L) x 210(W) x 50(H)mm

QV-3049

$249



HDMI Display Receiver

Allows you to stream videos, music and photos wirelessly from your computer or DLNA enabled Android Smartphone or Tablet to your TV via HDMI.

- Doubles as a Wi-Fi router
- Supplied with software and power adaptor (HDMI cable available separately)

AR-1914 **WAS $169**

$139
SAVE $30

Network 2.4GHz Digital Wireless 7" LCD DVR Receiver and Camera Kit

Simple, wireless and easy to install, this DVR kit is ideal for offices or retail stores where security is essential. Monitor everything with its 7" LCD screen, or remotely on your Smartphone. Records to a SD Card XC-4992 $47.95 each (available separately).

- 150m range
- Motion triggered recording
- Quad screen display
- Waterproof camera

QC-3678 **WAS $399**

$349
SAVE $50

Spare Camera Available QC-3679 $149

In store only.

Jaycar Electronics

Better, More Technical

5 Way Remote Controlled Power Board

Reduce wasteful power consumption from appliances in standby mode. This board features 4 remote controlled sockets and 1 always stay "on" socket. Connected appliances can be switched off individually or simultaneously.

- 240VAC
- 10A, 2400W
- Cord length: 900mm

MS-6154 **WAS $59.95**

$49.95
SAVE $10

Low Cost Home Automation

Don't spend tens of thousands of dollars to create a smart home. With our new low cost range of Wireless Home Automation, you can create a fully automated system and only spend a few hundred dollars.

Simple and easy to use, all sensors, controllers and swicth modules are operating wirelessly on 433MHz frequency at a max range of 100m (line of sight).

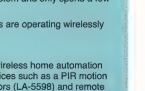
Home Automation Main Controller

A powerful controller with built-in 16 wireless alarm zones and 16 wireless home automation control. Easily interfaces with a wide range of wireless security devices such as a PIR motion detectors (LA-5157), magnetic reed switches (LA-5158), light sensors (LA-5598) and remote key fobs (LA-5155) to protect your home and property.

- Timer schedule programming
- Group programming
- Matrix (Scenes) programming
- 100 Alarm event memory
- 12VDC
- 240VAC power adaptor included

LA-5592

NEW!
$119



Accessories to suit:

Key FOB Remote	LA-5155 $19.95
PIR to suit	LA-5157 $49.95
Wireless reed switch to suit	LA-5158 $39.95

See Page 2 for more devices to suit.

TempMaster MK3 Electronic Thermostat Kit

DUE EARLY AUGUST

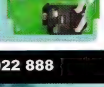
Ref: Silicon Chip Magazine August 2014

Convert a 240VAC freezer into a fridge, a fridge into a wine cooler or control heaters in home-brew setups, etc. or control 12V or 24V fridges or freezers. Supplied short-form with PCB, relay, temp sensor and components. Requires case, sockets and cable to suit your configuration.

- 12VDC / 150mA
- Immune to relay chatter problems
- Temp range: -23 to 47˚C
- PCB size: 80 x 104mm

KC-5529

NEW!
$39.95



Plug-in Surge Protector Mains Double Adaptor

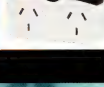
Protect your mains powered appliances from voltage spikes and surges. This surge protector also provides two USB ports for charging all the major mobile phones and tablets on the market.

- Max surge current: 1800 A
- Max USB output current: 3.5A (shared on both ports)
- Size: 91(W) x 72(H) x 55(D)mm

MS-4087

DUE EARLY AUGUST

NEW!
$29.95



750W 1500VA Line-Interactive UPS

Protect your valuable computer system from power failures, preventing data loss or corruption. An uninterruptible power supply (UPS) will seamlessly maintain power to your system with a battery and inverter in the event of a power failure. Back-up time 3 minutes at full load.

- Rating: 750W, 1500VA
- Output voltage 230VAC
- Size: 382(L) x 124(W) x 225(H)mm

MP-5203 **WAS $269**

$249
SAVE $20

Devices to suit Home Automation Main Controller LA-5592

240VAC Mains Switch Controller Module

Designed to be hard wired to your GPO, wall switches or other mains device, it enable you to remotely activate any mains appliances.

- Voltage input: 240VAC
- Wireless Range: 100m line of sight
- Wireless Frequency: 433MHz

LA-5594

$39.95

Also available: 12VDC Switch Controller Module LA-5595 $59.95

*Note: A licensed electrician is highly recommended to hard wire this device into 240V mains wiring.

240VAC Mains Light Dimmer Module

Remotely controls the intensity of your 240V lamps. It has 8 steps of light dimming, perfect for mood light setting when entertaining guests. Unit is only suitable for incandescent type bulbs.

- Voltage input: 240VAC
- Wireless Range: 100m line of sight
- Wireless Frequency: 433MHz

LA-5596

$39.95

*Note: A licensed electrician is highly recommended to hard wire this device into 240V mains wiring.

Wireless Infrared Controller

Mount on the roof to directly control your household appliances. Will learn your appliances infrared remote command and repeat them when matched with a home automation input device.

- Up to 150m² size of operation
- Voltage input: 12VDC
- Wireless Range: 100m line of sight
- Wireless Frequency: 433MHz

LA-5597

$79.95

Wireless Light Sensor Module

Interfaces with the home Automation System to turn an output device on or off.

- Adjustable light setting
- Voltage Input: 12VDC
- Wireless Range: 100m line of sight
- Wireless Frequency: 433MHz

LA-5598

$39.95

Wireless Bell Box

Works as an audible and visual deterrent, the siren produces a wailing 94dB of output and a powerful strobe when alarm is activated. Supplied with 240VAC mains power adaptor.

- Voltage input: 12VDC
- Wireless Range: 100m line of sight
- Wireless Frequency: 433MHz
- Size: 340(L) x 200(W) x 75(D)mm

LA-5579

$109

VIRIBRIGHT
The bright side of light

240VAC LED Downlight Kits

Fantastic DIY replacement of existing 50W halogen downlights, or a totally new installation. 2 pin power lead. Electrical safety approved.

- 8W, Dimmable

$34.95 ea
SAVE $5

Warm White
550 Lumens
SL-2300
WAS $39.95

Natural White
700 Lumens
SL-2302
WAS $39.95

200W Mains Dimmer Switch

Suitable for Dimmable LED Bulbs or Incandescent Lights.

PS-4084

$24.95

12V LED Lamps

A direct replacement for 35W halogen bulbs and provides up to 80% energy savings over halogen.

- 4.5W, MR16

ZD-0604

ZD-0600

$19.95 ea

DOWNLIGHTS

270 Lumens	Natural White	ZD-0600	$19.95
270 Lumens	Cool White	ZD-0603	$19.95
240 Lumens	Warm White	ZD-0602	$19.95
SPOTLIGHTS			
250 Lumens	Natural White	ZD-0604	$19.95
250 Lumens	Cool White	ZD-0605	$19.95
220 Lumens	Warm White	ZD-0606	$19.95

Temperature Measurement

Digital Fridge/Freezer LCD Mini Thermometer

See at a glance that your favourite food or beverage is at the correct temperature in the fridge or freezer. Hang it from a wire shelf, stand on a shelf or attach to a metal surface with the built-in magnet.

- Selectable C° / F°
- Temperature range: -19C° to 49°C
- Batteries: 1 x CR2025 included
- Size: 68(L) x 44(H) x 12(D)mm

QM-6323

NEW!
$9.95
DUE EARLY AUGUST

Wireless In & Out Thermometer and Hygrometer

Capable of measuring indoor and outdoor temperature, as well as relative humidity. LCD acts as a receiver unit for a separate outdoor sensor unit, and will receive information from up to 3 sensor units.

- Transmission range: Up to 100m open air
- Receiver size: 95(H) x 114(W) x 25(D)mm
- Sensor size: 51(H) x 63(W) x 25(D)mm

XC-0322

$29.95

Spare Sensor XC-0324 $14.95

8 Channel Wireless Thermometer with Jumbo LCD

Monitors temperature and humidity. The jumbo-sized receiver/LCD is for easy reading, up close and from afar. Displays real-time data, comfort and trend indicators and stores min/max records.

- Measures indoor/outdoor
- Receive up to 8 channels
- Temperature and humidity trend indicator
- Transmission range: approx 90m
- Size: 94(L) x 94(W)mm

XC-0328

$39.95

Additional Transmitter to suit: XC-0329 $17.95

Jumbo Display Thermometer/Hygrometer

Displays the temperature and humidity together on the one huge LCD display. It also has a min / max function (memory). Switch between C° and F°.

- Temperature: -10° - 60°C (14° - 140°F)
- Size: 110(H) x 100(W) x 22(D)mm

QM-7312

$24.95

Limited stock available

Remote Monitoring

4 Channel DVR

Ideal for small surveillance installations with 4 cameras or less and enables simultaneous viewing, playback, recording and backup operations. Supplied with a 500GB SATA HDD, software and manual on CD, power supply, and quick start guide.

- Remote access via Smartphone or web browser
- Built-in web server for network access
- Power supply: 12VDC 3.3A (included)
- H.264 video compression
- Size: 375(W) x 285(D) x 45(H)mm

QV-8120

$369

Also available: 16 Channel DVR
QV-8122 $899

Pan/Tilt DIY Wi-Fi IP Camera - 720p

Produces bright and sharp vision for you to survey the home or office remotely. Capture images or video to microSD card (available separately) when motion or sound is detected as well as send an email. Power supply included.

- Two way audio
- 10 x IR LEDs, night visibility up to 15m
- Angle: 320° Pan, 120° Tilt
- Size: 100(L) x 100(W) x 125(H)mm

QC-3839

$189

Network 16 Channel DVR with 1TB HDD

Records in WD1 (960 x 576) resolution from all 16 camera inputs, multiple video output formats including HDMI for local viewing, and an Ethernet connection which can be configured for remote viewing via a web browser or iPhone®/Smartphone application. It is also capable of accepting alarm trigger signals from separate sensors (required).

- H.264 video compression
- HDMI connection
- Motion trigger recording
- Power supply: 12VDC 5A (included)
- Size: 380(W) x 340(D) x 50(H)mm

QV-3039

$699

Professional 32 Channel Hybrid DVR

Capable of simultaneously recording video from a whopping 32 cameras(16 analogue + 16 IP inputs). Dual Core CPU allows recordings of 32 channels at D1 resolution (704 x 576) at 400 frames per second and multiplex the channels to a single video output. Live video and playback can be displayed through the HDMI, composite, or VGA outputs and accessed through a network connection using a web browser or a Smartphone app.

- 1TB HDD included
- Power supply: 100-240VAC
- Size: 460(D) x 440(W) x 89(H)mm

QV-8124 LIMITED STOCK. HURRY!

$1299

High Resolution Cameras with IR Illumination

Feature a high quality colour CMOS sensor and IR LEDs for night time illumination. Supplied with power supply and 18m combined video/power lead.

- 600 TV Lines
- Up to 10m range
- Power source: 12VDC

$99 ea

Outdoor Bullet Camera (IP66)
QC-8632 $99
Dome Camera
QC-8633 $99

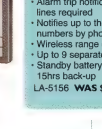
3-Axis Dome Camera 650 TV Lines

3-axis mechanism provides easy installation and enables you to put the camera's field of view exactly where you need it. Quality Sony sensors and optics.

- Sensor: 1/3" CCD

QC-8617

$119



Weatherproof IR Day/Night Camera

The camera comes housed inside a weatherproof case, with the latest dot-matrix IR LED, a fixed 3.6mm lens and a 600TVL resolution. Using only a single chip, the dot-matrix IR LED provides 120° of horizontal coverage and produces an infrared light output turning night into day.

- 600 TV Lines
- Dot-Matrix IR LEDs

QC-8627

$99

Access Control

2.5" LCD Video Doorphone with RFID Access

Suitable for home use, or areas requiring access identification/ authorisation. Consists of an outdoor camera with door bell/entry button as well as RFID access and a separate indoor 2.5" LCD for easily identifying visitors. Door locks are available separately to remotely lock/unlock the door.

- 2.5" colour LCD
- Master RFID tag, delete & slave tag included

QC-3622 **WAS $249**

$199
SAVE $50

Spare RFID Tag
QC-3623 $9.95

Intelligent GSM Wireless Alarm System

Incorporates a quad band GSM module which provides phone and SMS notification (GSM SIM card not included) when the alarm is triggered. Supplied with alarm control unit, power supply, 120dB siren, wireless PIR detector and wireless reed switch, and a wireless remote control.

- Alarm trip notification via GSM network no phone lines required
- Notifies up to three programmed numbers by phone and SMS
- Wireless range of 50m
- Up to 9 separate zones
- Standby battery: 9VDC for 15hrs back-up

LA-5156 **WAS $299**

$249
SAVE $50

Non-Contact Infrared Door Exit Switch

This infrared sensor can replace the old push button switch on automatic exit doors so that they will open with just a wave of your hand.

- 12VDC supply voltage
- 3A @ 30VDC contact rating
- 30mm sensor diameter

LA-5187

WAS $59.95

$49.95
SAVE $10

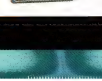
Digital Access Keypad

Self contained access key pad. Operates on 12V and only requires an electric door strike to provide a high level of secure access.

- EEPROM memory
- LED indicators

LA-5355 **WAS $39.95**

$29.95
SAVE $10



17" Colour LCD Monitor

High resolution slimline monitor suitable for surveillance applications. Its 4:3 aspect ratio means the camera vision won't appear distorted or stretched, unlike 16:9 monitors.

- VGA Input
- Size: 378(W) x 315(H) x 62(D)mm

QM-3577

$199

LIMITED STOCK. HURRY!

Pocket Size Gas Blowtorch

Fully self-contained butane 1300˚C portable blow torch. Simple press button Piezo ignition, flame control and safety lock. Refillable with butane gas (NA1020). Ideal for hobby use, low temp silver soldering, heat shrinking etc.

- Size: 95(H) x 55(L) x 26(W)mm

TH-1610

NEW!
$16.95

For suitable Butane Gas use NA-1020 $5.95
For Silver Solder use NS-3045 $19.95

Stainless Steel Wire Stripper and Cutter

Strip wire sizes from 0.6mm to 2.6mm. Spring-loaded with locking jaws. Soft rubber handles for added comfort.

- Strips stranded wire from 12-24 AWG and solid wire from 10-22 AWG
- Will also cut steel wires up to 3.0mm
- 164mm long

TH-1841

NEW!
$15.95

DUE EARLY AUGUST

Compression Crimping Tool - Universal

A precision crimp tool that employs a ratchet action ensuring correct crimping pressure is applied for reliable, trouble-free compression BNC, RCA, IEC, Min-F and F-type coaxial connectors. Adjustable compression depth.

- Works with RG59 and RG6 coaxial cables.
- 146mm long

TH-1800

NEW!
$19.95

DUE EARLY AUGUST

Inspection Camera with Detachable Screen

Capture video and pictures in confined and dark locations. The head and flexible boom are IP67 rated so both can be submerged in water during operation.

$249

- 2GB microSD card included
- 1m flexible boom
- 2.4GHz Wireless transmission frequency
- Hook, mirror and magnet included

QC-8712

Extension Shaft 2m QC-8702 $79

Cat III True RMS DMM with Temperature

A powerful true RMS multimeter that includes non-contact voltage testing, backlit LCD, and a carrying pouch.

- 4000 count, 600V
- Temperature Range 20°C~760°C
- Voltage, current, resistance, capacitance, frequency and more
- Powered by 1 x 9V battery (included)

QM-1551

$59.95

IP67 True RMS DMM with Smartphone App

View live measurements, trend graphs, data log, email your results and upload them to the Cloud - all from your Smartphone!

- CAT IV, 600V
- AC/DC voltages up to 1000V
- AC/DC current up to 10A
- Resistance, capacitance, requency and more
- IP67 waterproof
- Bluetooth® Smartphone/ PC interface
- Data log storage

QM-1576

$219

Professional Digital Light Meter

Extremely accurate with a rapid response and can store min and max values for easy comparisons. Measurement can be switched between LUX and FC (foot candles) and a data hold function is included for pausing the reading.

- Max 400K LUX

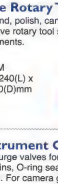
QM-1584

WAS $129 SAVE $30

$99

Compact Digital Sound Level Meter

Measures sound levels between 30 to 130dB and can be set for fast or slow responses. Data hold. Min/ max function. Backlit LCD. Supplied with carry case, wind sock and battery.



- 3.5 digit display
- 30 to 130dB
- 210mm long

QM-1589

$99

Economy Non-Contact Thermometer

Safely measure temperature in hot, hazardous, or hard to reach places with the built-in laser pointer directed at the surface.

- 8:1 Distance to spot ratio
- Auto data hold
- Carry case included

QM-7215

$49.95

60W ESD Safe Solder/ Rework Station

Complete solder/desolder station for production and service use. Temperature is easily adjusted in 1° increments with simple up/down buttons and the soldering/rework functions can be operated independently of each other.

- Microprocessor controlled
- Dual LCD displays
- Temperature range 160˚C to 480˚C
- Celsius and Fahrenheit display

TS-1574

$299

For spare tips and accessories, see website for details.

110 Piece Rotary Tool Set

Drill, saw, sand, polish, carve or grind with this comprehensive rotary tool set. See website for full list of attachments.

- 12V
- 12,000 RPM
- Case size: 240(L) x 200(W) x 70(D)mm

TD-2451

$29.95

Waterproof ABS Cases - Black

Use for storing or transporting Smartphones, radios, delicate electronic devices and more. Fully protected from water, dust and sludge.

- Protective foam

SMALL: 182(L) x 120(W) x 42(H)mm
HB-6421 $16.95

MEDIUM: 182(L) x 120(W) x 75(H)mm
HB-6423 $19.95

LARGE: 855(L) x 482(H) x 495(H)mm
HB-6425 $29.95

FROM $16.95

ABS Instrument Cases with Purge Valves

Come with purge valves for an airtight seal, ribbed ABS construction, stainless steel hinge pins, O-ring seals and very solid catches. For camera gear, test, medical or scientific equipment.

FROM $19.95

- 3 year warranty

HB-6389	173(W) x 125(D) x 50(H)mm	$19.95
HB-6388	210(W) x 135(D) x 90(H)mm	$34.95
HB-6381	330(W) x 280(D) x 120(H)mm	$54.95
HB-6383*	430(W) x 380(D) x 154(H)mm	$84.95
HB-6385	515(W) x 415(D) x 200(H)mm	$119.00
HB-6387*	530(W) x 385(D) x 225(H)mm	$175.00

*LIMITED STOCK. HURRY!

Foxtel IQ2 Compatible IR Remote Control Extender

Allows you to control your video source devices like Foxtel, a set top box, Blu-Ray/DVD player, or even a HDMI switcher from another room.

- Foxtel IQ2 compatible
- Up to 50m range
- Power supply: 9VDC/150mA

AR-1827 **WAS $49.95**

$39.95
SAVE $10

5.8GHz Wireless AV Sender

Transmits audio/video signals up to 50m clear line of sight. Interference free. Compatible with most PayTV systems and AV equipment. Built-in infrared extender.

AR-1878

$89

WATCH TV ALL OVER THE HOUSE

Spare Receiver AR-1879 $69

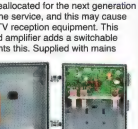
Kingray 4 Output Masthead Amplifier

Accepts a single "mixed" antenna input, and provides four amplified outputs for you to run to each wall point in your home. All connections are F-type to ensure best signal quality. Housed in a metal case. Includes power supply.

- Wide input range to suit all analogue and digital TV signals
- Suitable for combined VHF/UHF antenna input
- Size: 105(W) x 90(H) x 35(D)mm

LT-3253

$79.95



HDMI CONVERTERS

Connect a HDMI source like a laptop or Blu-ray player to display on CRT TVs or monitors equipped with RCA composite with the AC-1720. Enable old devices such as Sega master systems, DVRs, or VHS players to playback video and audio on more modern HDMI equipped displays with the AC-1722.

HDMI to AV Composite Converter

- HDCP support
- HDMI 1.3 compliant
- Requires 5VDC power supply (included)
- Size: 115(D) x 100(W) x 25(H)mm

AC-1720

NEW!
$99

AC-1720

Composite AV to HDMI Converter

- Supports HDMI 1080p 60Hz / 720p 60Hz output
- Requires 5VDC power supply (included)
- Size: 60(W) x 54(L) x 20(H)mm

AC-1722

NEW!
$74.95

AC-1722

Kingray VHF/UHF Masthead Amp

A large chunk of the Australian TV broadcast spectrum is being reallocated for the next generation 4G/LTE mobile phone service, and this may cause issue with existing TV reception equipment. This new 35db masthead amplifier adds a switchable filter to protect againts this. Supplied with mains adaptor.

LT-3251

$99.95

Remote Control AV Selector Switch

Connect up to 4 AV sources to one television and switch between them remotely. There are 4 x RCA composite/S-Video inputs and 1 x RCA composite/S-Video output.

- Size: 190(L) x 115(W) x 51(H)mm

AC-1654 **WAS $44.95**

$39.95
SAVE $5

Stereo Amplifier with Remote Control

Rated at a generous 100 watts RMS per channel and has a flat frequency response from 20Hz to 20kHz. Includes remote control to adjust input source, volume etc.

- 2 x 100WRMS
- Inputs for Tape, Tuner, AV1, AV2, CD, Phono

AA-0470

$179

Dual Channel UHF Autoscan Wireless Microphone

Suitable for professional and stage use, featuring 16 user-selectable channels on each microphone input to provide interference-free transmission, phase locked loop (PLL) circuitry for frequency stability. See website for full specifications.

- 12-18VDC
- Includes 2 microphones

AM-4120

$319

Wireless Lapel Microphone available:
Ch A AM-4067 $129
Ch B AM-4069 $129

Infrared Wireless Stereo Headphones

Dual-channel wireless headphones with a digital TOSLINK audio input to connect your digital devices for a variety of audio experiences.

- Quick and easy set-up
- Excellent sound clarity
- Operation distance: up to 15m (Infrared)
- Active noise reduction system
- Volume control and channel selection on headphones
- Multiple headphones can be used simultaneously with one transmitter
- Folds up for easy storage and transport
- Weight: 30g

AA-2038

NEW!
$59.95

Spare Headphones to suit NEW AA-2039 $29.95

Single Output Plug-in Indoor TV Booster

Simple and neat solution to boosts your TV antenna signals. Plug into a mains outlet for up to 20dB of signal amplification.

- F connector in, F connector out
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- Gain control: 15dB VHF, 10dB UHF

LT-3285

$39.95

Active Indoor Digital TV Antenna

A step up from conventional rabbit ears with 28dB variable gain. Suitable for VHF, UHF, FM and DTV reception. Mains plugpack included.

- VHF: 54 - 239 MHz
- UHF: 470 - 821 MHz
- Base Size: 190(L) x 120(W)mm

LT-3133

$44.95

UHF Phased Array TV Antenna

Suits analogue or digital TV and ideal for fringe areas, where ghosting is a problem.

- Receives Bands 4 and 5
- UHF channels - 21 to 69 (27 to 62 in NZ)
- Size: 840(L) x 540(W)mm

LT-3138

$69.95

Slim Ballast HID Light Kits

HID provides far greater light output than standard automotive lights. This series of kits all feature a slim ballast design for ease of installation in engine bays and tight spaces.

- 12V 6000K
- 300% more light than halogen

H1 Slim Ballast HID Kit	**SL-3490**	**$49.95**
H3 Slim Ballast HID Kit	**SL-3492**	**$49.95**
H4 Slim Ballast HID Kic	**SL-3494**	**$49.95**
H4 Slim Ballast HID High + Low Kit	**SL-3495**	**$79.95**
H7 Slim Ballast HID Kit	**SL-3496**	**$49.95**

Note: Please ensure your lights are angled correctly. These lights are not ADR approved.

FROM $49.95 LIMITED STOCK.

Vehicle Camera with Infrared LEDs

IDEAL FOR BUSES OR TRUCKS

This tough unit can be firmly mounted inside as a surveillance camera or outside as a reversing camera. The camera is fitted to a solid bracket that can be rotated in a vertical motion for the optimal view. Infrared LEDs for night vision view.

- IP67
- 12VDC
- Size: 73(L) x 45(W) x 53(H)mm

QC-3519

$129

GPS/GSM Tracking Device

A GSM and GPS Tracking solution to locate and track the whereabouts of your vehicle in real time via the Internet on a computer or Smartphone. It works by sending the vehicle's GPS coordinates via the GSM network (Sim card not included) to the free online tracking service, which shows the location on Google Maps.

- Built-in GSM & GPS antenna
- Real time upload current location to website
- Turn off car engine by Internet platform or SMS for Anti-theft
- Send alert when vehicle exits a restricted area or exceeds the restricted speed
- Size: 68(L) x 48(W) x 20(D)mm

LA-9011

$149

Vehicle shown using online tracking system

7" TFT LCD Widescreen Colour Monitor

Ideal for in-car entertainment, use it to watch DVDs, gaming consoles or with reversing cameras etc. Extremely lightweight and suitable for all sorts of mobile and fixed monitoring applications.

- 12/24V
- Includes remote control
- High resolution wide screen format

QM-3752

$99

Security & Monitoring

Wireless Tyre Pressure Monitoring Kit

Track PSI data from the 4 sensors fitted to your tyres on the 12VDC monitor in your car. High and low pressure alarm.

- Suitable for vehicles designed for 30-42PSI

QP-2298 **WAS $199**

$149 SAVE $50

Alternator & Battery Monitor

Simply plugs into your car's cigarette lighter socket to indicate alternator and battery status. Compatible with 12VDC systems.

PP-2142

$9.95

OBD2 Plug / Memory Saver

Use this memory saver lead to store, and restore all of your vehicles fault codes, radio settings, alarm settings, keyless entry codes, and more.

- 1m length

PP-2140

$9.95

4 Door Remote Controlled Central Locking Kit

Remotely lock and unlock your car doors. Install the security button to cut off the fuel pump to prevent the car being stolen. Supplied with 1 master actuator, 3 slave actuators, control relay, two remotes with batteries, kill switch, hardware and wiring loom.

- Working voltage: 9 - 16VDC
- Frequency: 433.92MHz

LR-8842

$79.95

Steelmate Entry Level Car Alarm

An affordable car alarm that features voice feedback on alarm status and operational parameters such as open doors etc. Comes with code hopping remotes.

- Boot release button
- Valet mode
- Anti-hijacking, emergency call & locating
- Emergency override

LA-9003

$99

Spare Remote **LA-9004 $37.95**

Controllers

Learning Key Fob Remote

Brand name replacement remotes for most alarm are expensive. Save yourself a bundle and buy one of these learning remotes instead.

- Frequency: 250 to 450MHz

LA-8992

$45

LIMITED STOCK. HURRY!

Single Channel Key Fob Remote

Multi-purpose remote control key fob for garage doors, lights automatic gates etc. It operates in the 27MHz band on an FM signal. Easy set-up and installation.

- Battery status LED
- Up to 200m range

LR-8847

$49.95

One Channel Hand Controller & Transmitter

Keep a spare or replace a broken garage door remote with this latest version of the most common transmitter in use in Australia/New Zealand today. The controller is custom coded via a DIP-switch which is accessible from the battery cover.

- Operates on 27.145MHz

LR-8827

$49.95

Wireless 3 Outlet Mains Controller

Plug in any mains appliance rated up to 10A and use the remote to turn each one on or off individually, or control all of them together. One of the outlets also has an LED night light that's also operated with the remote.

- 433MHz
- Remote battery included MS-6142

WAS $44.95

$34.95

SAVE $10

Spare Mains Outlet MS-6143 $17.95
Wireless Mains Remote & Outlet MS-6145 $24.95

24Hr Mechanical Mains Timer

Control any 240V mains appliance rated up to 10A even when away from home. Simply rotate the dial to the time you want, then switch it on.

- Size: 120(H) x 76(W) x 50(D)mm

MS-6112

$9.95

Digital Mains Timer Switch Modules

Ideal for automating your heating & lighting or practically any other switching application that requires multiple unattended switching cycles.

- Eight on/off settings

$49.95 ea

12VDC 16A
AA-0361 $49.95

240VAC 30A
AA-0362 $49.95

Power Monitoring

Mains Power Meter

The meter tracks the actual power being used. Shows instantaneous voltage or current being drawn as well as peak levels.

- 10A max rating

MS-6115 $19.95

3 FOR $45

SAVE $14.85

Large LCD Power Meter

Monitor the energy consumption of an appliance.

- Displays wattage, voltage and cost usage
- Supplied with 1m extension cable
- Size: 159(L) x 73(W) x 38(H)mm

MS-6119

$29.95

Mains Wireless Power Monitor

Wirelessly transmit data on power usage from your fuse box to the indoor display unit up to 50m away. Track and view consumption on the large LCD display.

- Batteries included
- Display unit size: 101(H) x 80(W) x 42(D)mm

MS-6160

$41.95

IN STORE ONLY. NOT AVAILABLE ONLINE.

Energy Saving Power Board

Save power and money by automatically switching off appliances when not in use. Operate with your existing remote control (e.g. TV remote). 6 sockets: 1 x control, 1 x always-on and 4 x auto-off sockets. IR receiver.

- Surge protected
- Rated 10A max
- Size: 340(L) x 120(W) x 35(D)mm

MS-4080 $69.95

Remote control not included

2 FOR $89.90

SAVE $50

Power Controllers

12V/24V 30A MPPT Solar Charge Controller

MPPT technology uses DC to DC conversion along with some electronic smarts to be able to extract the absolute maximum charging power from your solar panels, giving you up to an extra 10-40% from your solar panels when compared to a normal PWM charge controller, especially in low-light conditions.

- Microprocessor controlled MPPT
- 3-stage charging
- 30A automatic load control with low-voltage disconnect/reconnect
- Includes temperature sensor for battery charging compensation
- Protection against over voltage, reverse connection, short circuit, over current, and over temperature
- Size: 205(L) x 145(W) x 55(H)mm

MP-3735

$249

NOTE: Suitable for 12V or 24V solar arrays only.
A 12V solar array cannot be used to charge a 24V battery.

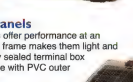
20A Solar Charge Controller with LCD Display

This microprocessor controlled unit is capable of handling all of your solar charging requirements and protect your battery. It has an array of features including adjustable charging voltage, automatic dusk-till-dawn on/off, overload protection, etc. See our website for full details.

- 12V
- LCD display

MP-3129

$149



12V 8A Water Resistant PWM Solar Charge Controller

Suitable for both wet-cell and sealed lead-acid batteries and uses pulse width modulation for optimal 3-stage charging. Compatible with all types of solar arrays and is potted in epoxy resin making it water resistance. Full specs available on our website.

- Battery voltage: 12VDC
- Size: 97(L) x 46(W) x 26(H)mm

MP-3720

$49.95

Semi-flexible Solar Panels

These 12V flexible solar panels offer performance at an affordable price. No heavy rigid frame makes them light and portable. Both units have a fully sealed terminal box with approx 1.2m of power cable with PVC outer sheath.

20W

- Short circuit current: 1.24A
- Weight 0.78kg

ZM-9112

$99.95

100W

- Short circuit current: 5.69A
- 2.8kg

ZM-9116

$399

12V 150Ah AGM Deep Cycle Battery

Designed to perform in harsh tropical conditions! With a superior high rate discharge performance and higher cycle service life, this battery is perfect for a wide array of applications including remote solar systems, 4WD, caravan and RV, motorhome, and marine. See our website for a full specification datasheet.

- Small footprint to suit installations in tight areas
- Voltage: 12VDC
- Weight: 52kg
- Size: 123(W) x 556(D) x 296(H)mm

SB-1822

NOTE: Not stocked in all stores but can be ordered. Call your nearest store for details

$699

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DATA CONTROL

Universal Wi-Fi Extender

Eliminate Wi-Fi dead zones and extend the range of existing networks. Just plug the unit into an existing power point in your home and within seconds it will help detect available Wi-Fi networks and establish connection using the iQ setup.

- 3 in 1 function: Range extender, access point & Wi-Fi bridge
- WPS (Wi-Fi Protected Setup)

YN-8360

$69.95

Also available:
Dual Band 2.4GHz/5.0GHz Model
YN-8364 $89.95

High Power Wireless Outdoor Router

With a wireless power of 600mW this unit has excellent point to point range with the installed internal directional antenna. If omni-directional transmission is required then you can connect an external antenna (sold separately) via the SMA connector at the base.

YN-8330

$89.95

3G & 4G TV Antennas

Using 3G/4G wireless Internet in certain areas may require the help of an antenna to boost the signal for a reliable flow of data. Both antennas features a very strong magnetic base so you can fix it to the roof of your car or any other steel surface. The cable is terminated with an FME connector.

5dBi - 2m Cable	**AR-3310 $49.95**
7dBi - 3m Cable	**AR-3312 $69.95**

FROM $49.95

USB 3.0 to HDMI Adaptor

Add an additional monitor or projector to your computer. Uses USB 3.0 to ensure smooth and responsive 1080p streaming. Supports desktop mirror, extend mode, multi-screen mode and rotation mode.

- Add up to four USB 3.0 adaptors simultaneously

XC-4973

$89.95

RS-232 DB9 to USB Converter

Connect a variety of RS-232 devices to your modern computer with this simple adaptor.

- USB 1.1 compliant
- Speed: Over 250kbps

XC-4927

$27.95

USB to DB9M RS-232 Converter

Allows a computer with a USB port to use any RS-232C serial device via the USB port. Suitable for digital cameras, modems, POS systems, ISDN terminal adaptors etc. Over 1Mbps data transfer rate.

- 1.5m long

XC-4834

$29.95

S-Video to VGA Video Converter

Ideal for connecting an old game console, VHS player, etc to your computer monitor or plasma TV. Has VGA loop through so you can have a computer and composite/S-video source connected to the same display.

XC-4906

$49.95

USB to DVI Adaptor

Connect your monitor to the computer via the USB 2.0 port without buying additional graphics cards. Use up to 6 simultaneously to run screen arrays.

- Powered via USB

XC-4879

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Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Savings off Original RRP.
Prices valid from 24th July 2014 to 23rd August 2014.

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Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock.

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SERVICEMAN'S LOG

Some things we just can't fix

Dave Thompson*

Biggles, one of our much-loved family cats, disappeared recently and I've been using some of my serviceman skills in an effort to track him down. Unfortunately, tracking down a missing cat is nowhere near as easy as finding faults in electronic gear or computers. There are some things which are beyond our powers but we still give it a go.

Items Covered This Month

- Some things we just can't fix
- Hybaid oven repair
- Krohn-Hite filter problem

*Dave Thompson runs PC Anytime in Christchurch, NZ.
Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz

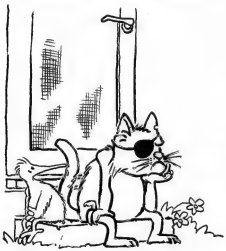
As servicemen, we are typically expected by family, friends and colleagues to be capable of fixing just about anything. Whether it's the switch on a neighbour's leaf blower, the power supply in a customer's DVD player or the range-finder on a radar-guided artillery canon, we're expected to take it all in our stride.

Of course, it's true that many technically-capable people are more at home pottering around in a workshop than mingling at a cocktail party. However, we take pride in the fact that not much gets past us. In most cases, we can fix whatever it is we are tasked with fixing.

This can-do attitude spills over into other aspects of our everyday life, in that we are more likely to have a go at something even if we're not completely up to par on the technology. Where others would (some say wisely) give up at the first sign of something being too hard or too complicated, we are more likely to roll up our sleeves and persevere.

As a result, we are generally more used to success than failure. If something goes wrong, we instinctively get on with sorting it out because solving problems is what we do. The feeling of a job well done is our ultimate goal and for some that is just as rewarding as any financial gain.

Of course, it's obviously unrealistic to expect that we should be able to fix everything, especially problems far outside our fields of expertise. However, that doesn't stop us feeling impotent and frustrated when we can't apply what skills we do have to help sort things out in such situations.



BIGGLES HAD TAKEN TO HANGING AROUND HOME A LOT MORE

Personal experience

I found myself plunged into one such scenario a few weeks ago when our much-loved family cat Biggles wandered down the driveway and, for all intents and purposes, vanished from the face of the earth. I've talked about Biggles before in respect of his wanderings and the fun and games we had trying to find a solution to keep tabs on the wayward little guy.

As mentioned, we eventually purchased a GPS tracking device but it turned out to be just too big for Biggles to lug around. It looked small in the photos and advertising blurb but in reality, it just wasn't small enough. Set up properly, it would be ideal for the likes of a Labrador-sized dog but sadly, it isn't suitable for a cat-sized cat. It's for sale by the way, should anyone want to try it out.

There were plenty of other ideas but since Biggles had taken to hanging around home a lot more (probably due to an unknown accident that resulted in him losing an eye), we didn't feel the need to further pursue tracking solutions. Of course, we are kicking ourselves now. Like all technology, the past year has seen great leaps in tracking devices for cats and we really should have had Biggles fitted out with one of these.

In fact, there is one device that looked so good that we bought two of them sight unseen for our other cats. They both now boast a very nifty locator collar that should help us track them down should they decide to wander off.

This particular device is very cool. Called the "Loc8tor Pet" (www.loc-8tor.com), it's an RFID-based system and uses a tiny transceiver that's mounted in a waterproof pouch fastened to the pet's collar. The second part is a hand-held, credit card-sized receiver that's capable of tracking up to four collars.

To locate the absent moggie, one simply turns it on, selects the collar required and turns in a circle. A bank of coloured LEDs and a beeping tone indicate the direction of the collar

TECHNICALLY CAPABLE PEOPLE PRACTISING "MINGLING" AT A COCKTAIL PARTY

within a range of about 200 metres.

Obviously, terrain and structures can reduce the effective range. However, we've tested this unit by walking down the street and it easily picks up our cats when they're inside our house and that's good enough for us. If only Biggles had been wearing this device; I'm sure we'd have had him back by now.

GPS microchips

With advancing technology, it's probable that the microchips eventually implanted into animals will be fully GPS-capable and allow pets to be accurately tracked. While such things do already exist, most require further development but give it a few years and they will be up to par. Pet microchips are certainly the way to go as far as identification and tracking go but every system can have its faults. For example, a while back there was a recall of chips that malfunctioned and lost their programmed information.

We found another potential flaw with the existing microchip system when we began talking to vets and checking the various lost and found pet registers for Biggles. It turns out that many vets here in NZ don't scan every animal that comes into their surgery as part of their routine. This means that it would be possible for a missing pet to fall through the cracks if, for example, someone took a stolen pet to the vet as their own.

In the course of posting "missing cat" flyers at all our local vets, I spoke to several about this very issue and they all confirmed they don't scan every animal, even if it's a first-time visit to the practice. Instead, they ask the owner if the pet is chipped but don't necessarily scan it. The answer, of course, would be to scan every animal coming through the door as routine but the vets I spoke to admitted that this was unlikely to be implemented.

Yet another potential flaw in the microchip system became apparent when I began calling the local council every few days, to see if any of their contractors had recovered Biggles. If members of the public report a deceased animal on the road, a council employee goes out and removes it (not the most pleasant job, I'm sure). He also provides a rough description of the animal and that gets logged with the council so that when people like me call in, the receptionist simply searches the database and goes through the list by type of animal, location and date.

For obvious reasons, I dislike calling them because there's always a nervous moment as they peruse the list for possible matches. So far though, nothing has turned up that matches Biggles.

But here's the flaw; the employees who pick up the animals don't have a microchip reader and neither is there one back at their base. Having one on-hand at either location would make their job so much easier and would be a lot more accurate.

Of course, it's a grim job but sometimes their descriptions of the unfortunate animal are rather scant, with no mention of gender, size, collar, street or other features. A relatively inexpensive chip reader would go a long way towards remedying that.

The bottom line is that with gaps like this in the system, we can't rely on it to locate Biggles. That said, the council does make an effort and it would be good if they could go just that little bit further and introduce a chip reader.

Shown here about two-thirds actual size, the Loc8tor Pet is an RFID-based system and is ideal for locating wayward cats. The company also has a GPS-based unit intended mainly for dogs.

Lost cat detector?

So were there any devices I could come up with that might help locate Biggles? I did eventually try a couple but in the early days our main concern was that he was trapped in someone's garage or garden shed.

As a result, the first thing we did was to door-knock every house in the immediate neighbourhood and ask the owners if they (or we) could look in their garages or other out-buildings for our missing cat. This is a relatively easy task when you know the neighbours but there are some people in the street we've never met or have had run-ins with over barking dogs and these were more difficult to approach.

We went ahead anyway and while the vast majority of people we approached were sympathetic, our searches turned up nothing. So short of designing and building a lost cat detector, there wasn't a lot I could do.

And that gave me an idea; perhaps a sensitive sound detector would work. As it happened, I'd built a high-gain 'spy' amplifier some years ago using a circuit from an electronics magazine. It's basically a 4-transistor amplifier that uses a condenser microphone and variable feedback to provide large amounts of gain.

This directional microphone with parabolic dish antenna was built up as a highly-sensitive sound detector. It can pick up faint sounds from hundreds of metres away.

When used with a pair of suitable headphones it can pick up faint sounds from hundreds of metres away and I figured that if Biggles was trapped somewhere, a walk around the neighbourhood with this would soon have him pinpointed.

Well, after a few hours of real-world experimenting with this device, I uncovered several serious problems. First, because of its high gain, every time a car went past or my wife called for Biggles, my eyes watered and my ear drums met in the middle. Also, with the microphone simply poking out the front of the case, it was woefully non-directional, with sounds behind us being picked up as clearly as those in front!

If this type of gadget was going to be any use at all I needed a parabolic dish antenna to make it highly directional. I also needed some way of reigning in the gain so that I wasn't deafened every time a loud noise occurred.

A quick Google search soon uncovered a similar circuit with automatic gain control, so I whipped this new amplifier together using stripboard and parts from my spares box. It worked a treat and a little experimentation with the gain control resistor soon had it set to the ideal automatic volume control level.

The next challenge was to find a parabola and after doing some reading, it seemed I could use anything from an umbrella to a frying pan lid, or even a large plastic ball cut in two. As a result, I visited several shops looking at everything from lamp shades to salad bowls.

I eventually settled on a stainless steel bowl that was almost the perfect shape and only cost $5. I had no idea of the focal length required so I mounted the microphone on an extendable cordless phone antenna I found in my junk box. This antenna measured just 75mm when fully retracted, which was shorter than required but was longer than required when fully extended.

Once I'd mounted the microphone centrally in the bowl, I listened into a sound source via a pair of 'over-the-ear' headphones and simply moved the mic in and out until I found the optimum position. It was all very unscientific and I could have used a signal generator and scope but time was of the essence and I needed to get out there and start listening.

After a few days of use, we'd heard many cats but none of them was Biggles. It could be argued that it was all a waste of time but it's a classic example of me feeling powerless yet trying to do something that was within my field of expertise to help.

Fooling the printer

Another thing we did was to post flyers in nearby letter boxes and put up lots of posters around the neighbourhood. We printed them ourselves using a colour laser printer I'd bought some time ago and we were staggered to find that the $80-plus toner cartridges needed replacing after only a few hundred prints. What was annoying was that these toner tanks had little clear windows on the side and I could still see toner inside.

A quick Google search confirmed my suspicions; there was apparently still as much as 40% of the toner remaining but a counter was "telling" the printer that the cartridge was empty, so I couldn't use them as they were. Another search revealed a simple fix for the problem; all I had to do was remove a cover from one end of the toner cartridge, pull back a spring and rotate the counter wheel back to its original position.

Serviceman's Log – continued

In use, a lever attached to this wheel trips the mechanism after so many copies and tells the printer that the toner cartridge is empty, even when it isn't. Manually resetting it fools the printer into thinking that the cartridge is new.

I tweaked all four and those same toner cartridges were still usable several hundred more copies later. Do some research and give this 'hack' a go if you are appalled at how little use you get from your own colour toner cartridges.

Indirectly then, being a serviceman has helped in our search for Biggles but so far we haven't found him. We're not about to give up though and if there's something else I can build or modify that might help locate him, you can bet your life I'll be doing it.

That's all part of the challenge of being a serviceman!

Hybaid oven repair

Some faults have quite 'violent' symptoms but are easy to track down and fix. K. D. of Chermside, Qld recently fixed two ovens that went 'bang' . . .

I recently had two simultaneous failures of "things that get hot" – one at work and one at home. Fortunately, both were simple physical faults that required only a little detective work to track down.

Fault number one occurred in a Hybaid HB-OV-1 "hybridisation" oven that's usually used in our laboratory to incubate samples for molecular biology. In addition to maintaining a stable temperature of about 70°C, these ovens have a simple mechanism for rotating the sample vessels inside. I'd been told that this one didn't work but that "it's only the fuse".

The fuseholder was incorporated into the IEC power inlet socket but the holder was jammed in place. When I finally prised it free, I found that the 3.2A M205 fuse was a pile of broken and blackened glass and the plastic had charred. I couldn't see any other problems, so I replaced the IEC socket and fuseholder and confirmed that the earth continuity and insulation resistance were acceptable. I then applied power and the oven ran perfectly.

After test running it for two days without problems, I returned the oven to service. So it looked like the user had been correct and it was just the fuse

Unfortunately, this 'cure' proved to be short-lived. About a week later, another user placed a sample into the oven and closed the door. As they did so, there was a loud bang and the oven went dead. This time the fuse tray was actually ejected from the inlet and the fuse in the Active line had blown apart with great force. I don't believe in coincidences – two fuses don't fail violently for no reason.

The failure was clearly related to closing the oven door. However, there are no switches activated by the door, so it was just the vibration involved that had triggered the failure.

I replaced the IEC socket/fuseholder once more and checked the resistance from Active to Earth. It showed an open circuit but I knew there had to be an intermittent short somewhere. A few gentle taps didn't reveal anything, so I bounced the oven up and down rather vigorously on the bench and eventually saw a brief flick of the meter's needle.

Stripping off the covers quickly revealed the culprit. The element was held in place by clips made from spring steel but after years of thermal cycling, they had lost their grip. As a result, vibration from the fan and the door had caused them to move slightly and the one on the Active side of the element had moved far enough to intermittently short the contact to chassis.

I re-tensioned the clips and added a spot of JB Weld to ensure that if they ever do loosen their grip again, they can't migrate and cause a short. A week of testing and even more vigorous bouncing confirmed that the fault had been fixed.

Coincidence

By coincidence, one night during that week of testing, I was cooking dinner at home when there was a bang from inside the cooktop (an Ariston PL6 04 GB) and I was plunged into darkness. I immediately went to the

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Krohn-Hite filter problem

Allan Linton-Smith, of Turramurra, NSW ran into a problem with a variable filter unit when designing the Majestic Loudspeaker System described in the June 2014 issue of Silicon Chip. Here's what happened . . .

During the design and testing of the Majestic Loudspeaker project, an old Krohn-Hite Model 3200/3202 filter was taken out of mothballs to act as a variable active crossover. This device is a solid-state, dual-channel, 24dB/octave filter and is continuously variable between 20Hz-2MHz. It has an insertion loss of 0dB and a specified hum and noise figure of 100μV.

Basically, it can be used as a variable high-pass filter, a low-pass filter and as a band-reject filter. By setting one channel on low pass and the other on high pass, it was easy to set a crossover point for the drivers used in the Majestic loudspeaker. In practice, the two audio signals from the filter were fed to two power amplifiers which then fed the woofer and tweeter in a bi-amped arrangement.

The idea behind this was to save time. Instead of experimenting with different fixed crossover networks, it would be relatively easy to determine the best crossover point for this system just by dialling a knob or two. In addition, any adjustments in level between the woofer (97dB/1W @ 1 metre) and the tweeter (110dB/1W @ 1 metre) could easily be made by using a 100kΩ level pot at the input of each power amplifier.

Initially, the filter was connected to a CD player and the crossover set to 2kHz. The sound that emerged was horribly distorted and so the filter was removed and taken to the workshop to see if it could be repaired. It was manufactured over 30 years ago but it was state-of-the-art back then! In fact, the technical sheet states that "Krohn-Hite . . . offers for the first time, an all solid-state variable electronic filter!"

Because it was a good-looking well-made (in the USA) instrument, it deserved a quick look instead of just chucking it out.

The first suspects were noisy transistors in the buffer stages. Perhaps it could be fitted with a more modern buffering amplifier based on low-noise ICs? The THD+N measured around 4% on both channels and things looked bad. However, when a 400Hz high-pass filter was switched in (this is an internal filter in my Audio Precision Analyser), the THD+N dropped dramatically to around 0.1%. This indicated that the problem was being caused by lots of hum and a quick check with a scope confirmed this.

Opening the device up was easy as it has four sliding panels which are held in place with just a few screws. Removing these panels exposed everything within the chassis. It was like viewing the components in 3D! Krohn-Hite really understand servicing requirements!

There were two separate channels, each with its own power supply and each with dual rails of ±16V. Each power supply had two 500μF 45V electrolytic filter capacitors and these were high on my list of suspects. A quick check on the AC components of these dual rails gave approximately 1.3V peak-to-peak for both channels!

I checked one of the filter capacitors and it measured around 600μF, so that one seemed to be OK. This meant that one or more of the others were probably faulty but the wiring around these components was very complex. As a result, they were left in place until replacements could be obtained.

Given their age, it made sense to replace all four. The original capacitors were chassis-mount types and I was unable to source direct replacements. In the end, I opted to use 5600μF 45V units from Jaycar (Cat. RU-6709). These have the same diameter as the originals but have pigtails rather than lugs.

Fortunately, the existing chassis clamps fitted perfectly, so it wasn't a problem to change these four capacitors. A quick check of the AC component on the DC supply then indicated 2.5mV and 3.0mV peak-to-peak, which was a significant improvement. But would it help?

A check on the Audio Precision Analyser now showed that the THD+N at 1V RMS input was 0.027% on one channel and 0.028% on the other. The residual noise was 18.60μV on one channel but was 208μV on the other. That's higher than the specification of 100μV but it can be forgiven on the grounds of age and the likely deterioration of other components.

switchboard and found that both the cooktop and main circuit breakers had tripped.

In view of this, I suspected that either the cooktop's element or its control had shorted, so I switched off the element I was using, reset the breakers and finished cooking on another element. I also removed the knob for the faulty element to remind myself not to use it.

A few days later, before I'd looked into the first failure, the same thing happened again while I was using a different element. Of course, it may have been a coincidence but as I've said before, I don't believe in those.

The following weekend, I removed the cooktop from the counter and ran a few basic checks. These checks revealed no short circuits, gave sensible resistances for the element ratings and revealed only minimal (normal) leakage via the elements. So the elements and controls were all OK.

Next, I turned my attention to the neon indicator. This was supposed to light when an element was on but had never worked during the five years I'd lived in the house. The reason for this was now obvious – the neon assembly was floating loose, as the plastic housing had turned brittle and broken away from its bezel.

What remained of the neon was covered in soot, the result of a short circuit to the cooktop's chassis. So the fault was quite simple and would be easy to fix.

An identical neon in the oven (Ariston FM81R IX AUS) had never worked either, so I dismantled the oven for a closer look. The body of this neon had also gone brittle and broken away but it was sitting well clear of the chassis. Both neons were replaced with a more robust type and there were no more problems. SC

The 2014 – improved version – of our popular electronic thermostat

By JIM ROWE

Here's a new and improved version of our very popular TempMaster electronic thermostat. It's ideal for converting a chest freezer into an energy-efficient fridge, converting a fridge into a wine cooler or controlling heaters in home-brew setups, hatcheries and fish tanks. It controls the fridge/freezer or heater directly via its own power cable, so there's no need to modify its internal wiring. It can even be adapted to control 12V or 24V fridges or freezers.

TEMPMASTER MK3

Our new TempMaster is smaller, easier to adjust, has a wider temperature range and is now virtually immune to relay chatter problems.

The previous version of the TempMaster was described in the February 2009 issue of SILICON CHIP and it has been very popular but as with most products, actual field use demonstrated that improvements can be made. Some common problems involved 'relay chatter' and motor switch-on/switch-off 'stuttering' when controlling fridges.

Typically, readers also wanted a different temperature range – either above or below the range of 2-19°C we had given the TempMaster Mk2.

We had in mind a number of changes and improvements to the February 2009 design but things were brought to a head by a design recently submitted by reader Alan Wilson. He effectively solved the noise sensitivity and relay chattering problem by providing a fast attack/slow decay filtering function, employing the previously unused second comparator in the IC package. So our new version of the TempMaster includes his modification.

We have also expanded the temperature adjustment range, reduced the already low quiescent power consumption and it now fits into a smaller and cheaper case. So here is the list of improvements and changes:

- *Much greater noise immunity and hence almost complete freedom from annoying relay chatter and motor switching stutter.*
- *A much wider overall temperature adjustment range (from -23°C to +47°C), which can be set by changing 'max' and 'min' jumper shunts rather than having to change resistor values.*
- *The use of a more efficient low-voltage regulator and CMOS dual op amp, lowering the quiescent power consumption to below 45 milliwatts (0.045 watts) – equating to 1.08Wh/day while running from battery.*

How it works

Fig.1 shows the basic configuration of the TempMaster Mk3 when it's set up for controlling a fridge or freezer.

The heart of the circuit is the remotely-mounted LM335Z temperature sensor, TS1. The LM335Z acts similarly to a special kind of zener diode but its voltage drop varies in direct proportion to absolute temperature, having a value of 0V at 0 Kelvin (-273°C) and rising linearly by 10mV for every Kelvin (or °C) rise in temperature.

This is shown in the graph of Fig.2. At a temperature of -10°C (263K), the voltage drop of the LM335Z is very close to 2.63V. Similarly at 40°C (313K), it rises to 3.13V. We use this change in voltage to control the temperature of our fridge/freezer or heater by comparing the sensor's voltage with a preset reference voltage.

The comparison is made by IC1a, one section of an LMC6482AIN dual CMOS op amp which is connected as a comparator. For cooling control, the sensor voltage V_{SENSOR} is fed to the non-inverting input, pin 3, of IC1a via a 1.2kΩ resistor, while the reference voltage V_{REF} is taken from adjustment trimpot VR1 and fed to the inverting input, pin 2.

If V_{SENSOR} is lower than V_{REF} (because the temperature of TS1 is lower than that corresponding to V_{REF}), the output of IC1a will be low – close to 0V. But if the temperature being sensed by TS1 should increase to the set threshold, V_{SENSOR} will rise just above V_{REF} and the output of IC1a will switch high – to almost +12V.

Heating

The reverse sequence of events happens when the circuit is configured for heating control rather than cooling. In this mode, sensor TS1's voltage V_{SENSOR} is fed to the inverting input of IC1a, while the reference voltage V_{REF} is fed to IC1a's non-inverting input via the 1.2kΩ resistor. (In other words, the two voltages are swapped around.)

As a result the output of IC1a remains low while ever V_{SENSOR} is higher than V_{REF} but switches high as soon as V_{SENSOR} falls below V_{REF}.

Hysteresis

Returning to the cooling control configuration shown in Fig.1, note the 10MΩ resistor connected between the output of IC1a (pin 1) and its non-inverting input (pin 3). This is to provide a very small amount of positive feedback.

We do this so that once pin 1 has switched high, the actual voltage fed to pin 3 will be slightly higher than the sensor voltage V_{SENSOR} (about 1mV higher, in fact). As a result, V_{SENSOR} needs to fall slightly below V_{REF} before the voltage at pin 3 drops to the level matching V_{REF}. But then pin 1 suddenly switches low again, which causes the voltage at pin 3 to drop back to V_{SENSOR}.

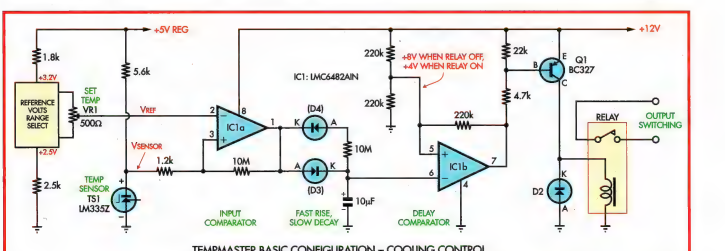
So the effect of this small amount of positive feedback is to create a small difference between the comparator's turn-on and turn-off voltage levels (and the corresponding temperatures).

This is called "hysteresis" and is designed to minimise any tendency for the comparator to oscillate or 'stutter' at the switching thresholds – especially the turn-off threshold.

Now we come to the improvement proposed by reader Alan Wilson, involving diodes D3, D4 and IC1b. Together with the 10µF capacitor and the second 10MΩ resistor, D3 & D4 form a fast-attack/slow-decay filter. This works in conjunction with IC1b (connected as a comparator) to ensure that transistor Q1 and the power switching relay are able to turn on quite rapidly as soon as the output of IC1a switches high but cannot switch off again for 30 seconds or so after the output of IC1a has dropped low.

This is because the 10µF capacitor can charge up quickly via D3 but can only discharge quite slowly via D4 and the 10MΩ resistor – and only when the output of IC1a has dropped low, in any case.

IC1b also has a modest amount of positive feedback ap-



TEMPMASTER BASIC CONFIGURATION – COOLING CONTROL

Fig.1: this simplified circuit shows the basic operation. The full circuit is shown overleaf in Fig.3.

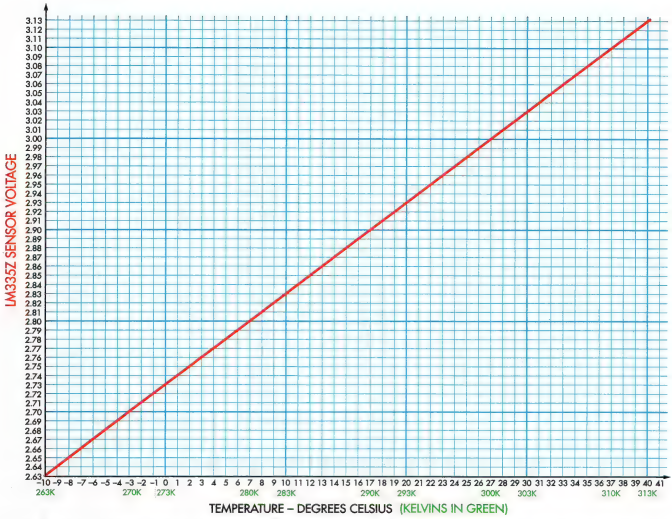


Fig.2: the LM335Z sensor voltage changes with its temperature, and that change is linear from way below zero up to above the boiling point of water. Actual operating range is -40°C to +100°C.

plied, via the 220kΩ resistor linking pins 7 and 5. This also helps ensure that there can be no relay stuttering during either turn-off or turn-on.

The full circuit

Now let's look at the full circuit of Fig.3 to consider the finer points of operation. Temperature sensor TS1 plugs into socket CON2 which connects to test point TP2 and one end pin of links LK1 and LK2. It also connects to the regulated +5.0V rail via a 5.6kΩ resistor, which feeds the sensor a small bias current. The regulated +5.0V rail is provided by REG1, an LP2950ACZ device.

The reference voltage to be compared with the sensor voltage is derived from the same regulated +5.0V supply rail, via a voltage divider formed by the 1.8kΩ resistor (at the top) – plus a string of 200Ω and 100Ω resistors and finally the 2.4kΩ resistor at the bottom.

The divider provides a set of five different tapping voltages, with +3.2V available at the top and +2.5V at the bottom. Link set LK3 allows you to select one of three voltage levels as the temperature range maximum, while link set LK4 allows you to select one of another three voltages as the temp range minimum.

The temperature setting 'fine tuning' is done using VR1, a 500Ω multi-turn trimpot. Its two ends are connected to LK3 and LK4 respectively, so whichever maximum and minimum temperatures have been selected using these links, VR1 then allows you to select any specific V_{REF} in this range, corresponding to your desired threshold or 'set point' temperature.

For example, if you have set LK3 to position 3 to give a maximum V_{REF} of 2.7V, and have also set LK4 to position 3 to give a minimum V_{REF} of 2.5V, VR1 will then let you select any voltage between these two limits. This means you'll be able to select any threshold temperature between about -3°C and -23°C. Get the idea?

Note that the selected reference voltage V_{REF} is made available at test point TP1, while the sensor voltage V_{SENSOR} is always available at TP2.

These two voltages go to links LK2 and LK1, which are used to select either the heating (H) or cooling (C) mode of operation. As mentioned earlier, this involves simply swapping which of the two voltages, V_{REF} and V_{SENSOR}, is passed to the non-inverting input of IC1a, and which is fed to the inverting input.

The rest of the circuit is very similar to the basic outline in Fig.1. The only real differences are the addition of small filter capacitors between both inputs of IC1a and IC1b (to

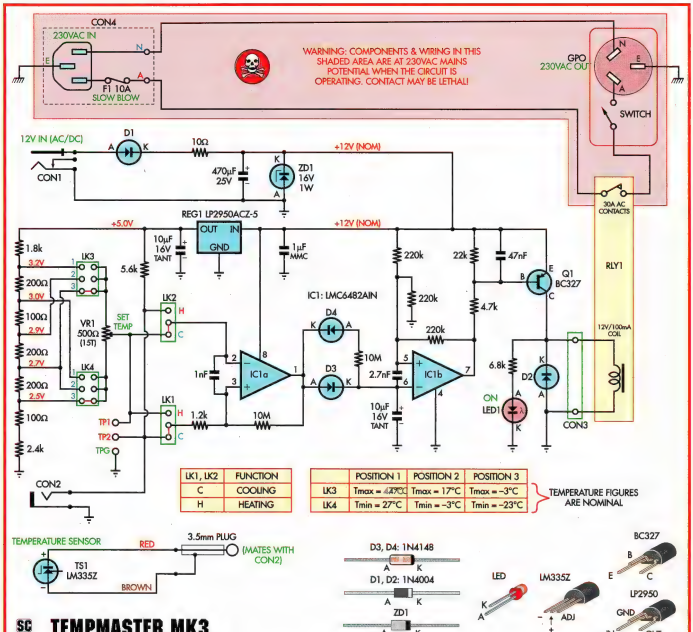


Fig.3: this full circuit of our new TempMaster has many similarities with the simplified version of Fig.1. While the control circuitry operates from low voltage and is isolated, it is switching mains so must be regarded as dangerous.

improve noise immunity), and the addition of LED1 with its 6.8kΩ series resistor, across the relay coil. This is to provide an indication of when the relay is energised.

All of the circuit operates from 12V DC fed via CON1, polarity protection diode D1 and a 10Ω resistor which limits the current through zener diode ZD1 if the voltage rises above 16V.

The supply can come from a 12V plugpack or battery, and since the current drain is only around 100mA when the relay is switched on and less than 4mA when it's off, only a small battery or plugpack is required. This should make the TempMaster Mk3 very suitable for use with solar power systems.

Construction

Nearly all of the components used in the TempMaster circuit are mounted on a PCB measuring 104 x 80mm and coded 21108141. The board has rounded cut-outs in each corner so it fits inside a sealed polycarbonate case measuring 115 x 90 x 55mm, sitting on the tapped pillars moulded into the bottom of the case.

We have used a rugged 12V relay (RLY1) rated to switch 250VAC at up to 30A so that it can easily handle typical fridge, freezer or heater loads. The connectors for the 12V DC input (CON1) and remote temperature sensor TS1 (CON2) are mounted on the right-hand side of the board, accessed via matching holes on that side of the case. The "set temperature" trimpot VR1 is mounted between these two connectors and is also accessed by a small hole, while the "relay on" indicator LED1 is visible via a similar small hole below CON2.

The only components not mounted on the PCB inside the

TempMaster Mk3 itself are the fused IEC mains input connector (CON4) and the switched 3-pin mains outlet or GPO. The latter is mounted on the lid, while the former mounts in the left-hand side of the case (in a matching cut-out).

Note that CON4 should be fastened inside the case using two 10mm Nylon screws and Nylon hex nuts.

When wiring the board, follow the internal photos and Fig.5 closely.

Begin wiring up the board by fitting the three terminal pins (used to provide test points TP1, TP2 and TPG). These go at centre right on the board. Then fit DC input connector CON1, temperature sensor socket CON2 and the two-way terminal block CON3 (used for the relay coil wires). If you want to use a socket for IC1 this can be fitted now as well.

You can also mount the two three-way SIL headers for LK1 and LK2, which are located just to the left of TP1. Then fit the two 3x2 DIL headers for LK3 and LK4, which go just above LK2.

Next install the various fixed resistors, making sure each one goes in its correct position. Check their values with a DMM just before it's fitted to the board. Then fit trimpot VR1, between CON1 and CON2.

The five non-polarised polyester and MMC capacitors can go in next, followed by the two 10µF tantalums and finally the 470µF electrolytic. Note that the last three are polarised and must go in the correct way around.

Then fit diodes D1-D4, zener diode ZD1 and transistor Q1, again paying attention to polarity. LED1 should be mounted vertically and with the bottom of its body about 15mm above the board (the leads will be bent by 90° later). Make sure the LED is orientated so that its 'flat' is near the top of the board and its longer anode lead is passing through the lower hole in the board.

Then solder REG1, followed by IC1 – soldering it in place if you're not using an IC socket.

Relay RLY1 is attached to the board using two M4 x 10mm machine screws, with flat washers, lockwashers and hex nuts. Before you mount it, you need to cut a small piece from the relay's mounting flange at the switching contacts end, as shown in Fig.5. (This is to provide clearance for the body of CON4, when it's fitted later.) The soft plastic can be cut quite easily using a small hacksaw and the cut edges smoothed using a small file.

Then mount the relay on the PCB with its coil connection spade terminals at the bottom and its contact connectors at the top, again as shown in Fig.5. Also make sure that you fit the relay mounting screws facing upwards – that is, with their heads under the board and the nuts and washers above the relay mounting flanges. Otherwise the PCB assembly won't fit properly down inside the case.

With the PCB now complete, you drill and cut the various holes needed in the case and its lid. The drilling and cutting details are shown in Fig.7.

Note that the cut-out in the rear long side of the case/box for fused IEC mains inlet CON4 extends almost to the very top – but not quite. Drill and file the cut-out first so

Full-size photo of the assembled PCB. All components (with the exception of the IEC mains input socket and the GPO) mount on this board. Note the double-insulating layer of heatshrink tubing over the coil wiring between the PCB and the coil spade terminals.

that it extends almost to the top of the outer box side and then carefully extend the top using a small file, until CON4 just slips inside.

Once the case is prepared, lower the PCB assembly down into the main part of the case until it's resting on the standoff pillars. Then decide where the leads of LED1 will need to be bent outward by 90°, so it will just protrude from the matching hole in the side of the case. When you have bent the LED leads to achieve this, lower the PCB assembly into the case again and screw it into place using four M3 x 6mm machine screws, which mate with the metal nuts moulded into the standoffs in the bottom of the case.

Then fit the IEC mains input connector CON4 into its cut-out and secure it with two M3 x 10mm Nylon screws and nuts.

Mount the mains outlet GPO on the case lid, with its 'backside' passing through the matching rectangular cut-out. This is done by unclipping the outer dress cover plate, to reveal the various recessed mounting holes which are provided.

The holes you'll be using here are those that are spaced 84mm apart, along the 'east-west' centreline of the GPO. You need to attach the GPO to the case lid using a pair of

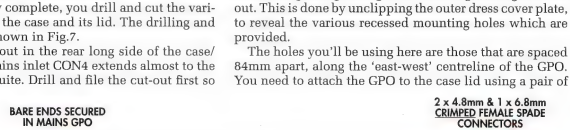


Fig.4: the cable connecting the input and output sockets should be cut from a 10A 3-core mains cable offcut.

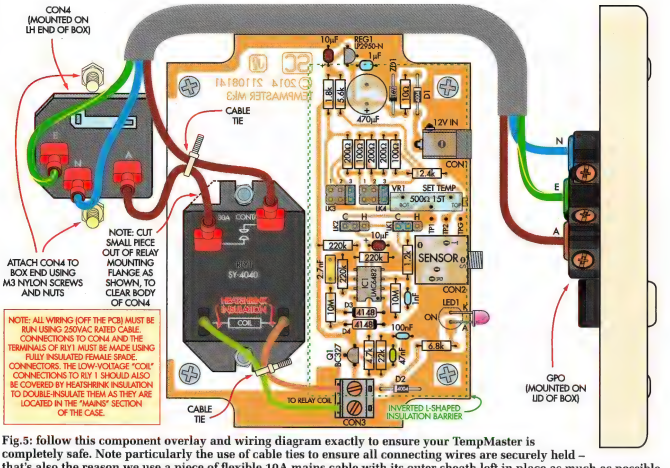


Fig.5: follow this component overlay and wiring diagram exactly to ensure your TempMaster is completely safe. Note particularly the use of cable ties to ensure all connecting wires are securely held – that's also the reason we use a piece of flexible 10A mains cable with its outer sheath left in place as much as possible.

M4 x 15mm pan-head screws passing down through these holes and fitted with star lockwashers and M4 nuts inside. Tighten these up firmly to make sure that the GPO can't work loose.

Don't fit the GPO's dress cover plate at this stage. It's clipped on later - after the lid is finally screwed onto the case, because the cover plate just interferes with the lid-to-case assembly screw heads.

Next you need to prepare the mains connection cables which link the GPO to the IEC mains connector and the contacts of RLY1.

Fig.4 shows a same-size diagram of the mains connecting cable. It makes sense to use a length of thin mains-rated 10A flex for this as you will not only obtain the insulation level required but leaving the outer sheath on the cable also keeps the conductors together.

Note that the blue (Neutral) and green/yellow (Earth) wires from the GPO have 4.8mm fully insulated female spade connectors crimped firmly to their 'far ends' while the brown (Active) wire has a 6.8mm spade connector attached. The shorter brown (Active) wire connecting from the IEC connector active to the relay switch contact also has insulated spade connectors at both ends, one 4.8mm and one 6.8mm wide.

Make sure you attach all of these spade connectors very firmly using a rachet-type crimp connector, so they will

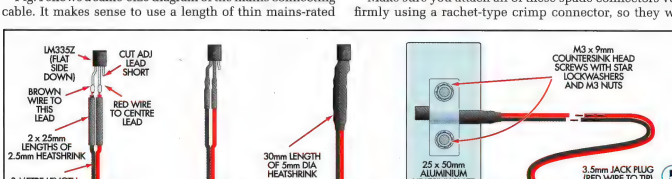


Fig.6: steps in wiring the LM335Z temperature sensor. In step 1, the unwanted "ADJ" lead is cut off, two wires are soldered to the other pins and then covered with heatshrink. In step 2, the heatshrink is slid up and over the soldered leads and shrunk, followed by a larger length of heatshrink over the whole assembly. In step 4, you secure the sensor to a heatsink, then finally in step 5 connect the two wires to a 3.5mm jack plug.

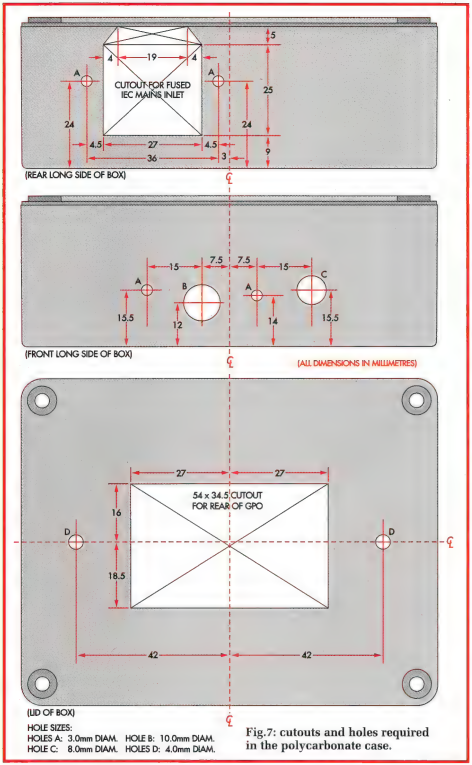


Fig.7: cutouts and holes required in the polycarbonate case.

give reliable long-term connections.

Lastly you can make up the two short wires which are used to connect the coil of RLY1 to terminal block CON3. These can be made up from medium-duty insulated hookup wire, with each one having a 4.8mm insulated female spade connector crimped to one end.

Once all of these wires have been prepared, you can use them all to connect everything up as shown in Fig.5. This will complete the wiring of the TempMaster Mk3, but before you screw on the lid of the case to finish assembly, fit a Nylon cable tie to the mains wiring as shown in Fig.5 and the internal photo. This is to ensure that should any of the spade connectors somehow work loose, there is no way that it can swing around and make contact with any of the low voltage wiring.

You can also fit another cable tie around the wires from the relay coil to CON3, to make sure these will also hold each other in place.

Now you can fit jumper shunts to the two 3-way SIL header strips LK1 and LK2, in the centre of the PCB, depending on whether you're going to be using the TempMaster to control cooling or heating. You should also fit jumper shunts to one of the three positions on both DIL header strips LK3 and LK4, to set the maximum and minimum of the temperature adjustment range you wish to use.

Safety insulation

Because there are low voltage components in close proximity to the mains outlet when the case is closed, it is essential to make sure they can never come in contact with each other.

We do this with an insulating barrier, cut from a piece of Presspahn, Elephantide or similar insulation and bent it into an "L"-shape (as shown in Fig.8). This slides down the edge of the relay, keeping the mains and low voltage sides separate.

A dollop of glue on the edge of the relay and the surface of the PCB alongside will hold the barrier in place when the top goes on.

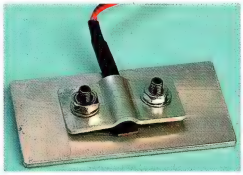
Fit the rubber sealing strip around the groove in the underside of the case lid and then screw the lid to the case using the four screws provided. Then you'll be able to clip the cover plate back on the GPO, to complete the assembly of the TempMaster Mk3 itself.

Making the remote sensor

The details for the temperature sensor are shown Fig.6. The first step is to clip short the unwanted third lead of the LM335Z sensor and then solder the ends of a 2-core ribbon cable to the other two leads after slipping 25mm lengths of 2.5mm diameter heatshrink sleeving over each one.

After the solder cools, the sleeves are then moved up until they butt hard against the body of the LM335Z. Then they are heated to shrink them in place (step 2). Then a 30mm length of 5mm diameter heatshrink sleeving is slipped along the cable and over the other sleeves, and heated in turn to shrink it in place as well (step 3).

Prepare the sensor's heatsink assem-



A close-up of the heatsink and clamp assembly for the LM335Z temperature sensor.

bly by drilling two 3.5mm diameter holes on the centre line of the 50 x 25mm aluminium plate, 18mm apart. The bottom of both holes should be countersunk to accept countersink-head screws passed up from underneath.

Next make the 30 x 10mm piece of 1mm aluminium into a clamp piece, by bending its central 8mm section into a half-round shape to fit snugly over the LM335Z body. After this drill 3.5mm holes in the flat ends of this clamp piece, 18mm apart again to match the holes in the larger plate. You should then be able to assemble the probe with the LM335Z clamped to the top of the plate 'flat side down', and the screws tightened down using M3 nuts and star lockwashers (step 4).

Complete the sensor assembly by fitting the 3.5mm mono jack plug to the other end of the two-core ribbon cable, connecting the red wire to the 'tip' lug and the brown wire to the 'sleeve' lug (step 5).

Initial checks

Before doing anything else, use your multimeter or DMM (set to a low ohms range) to check between the Earth pin of the IEC connector (CON4) and the Earth outlet of the GPO. You should get a reading of zero ohms here (this checks the integrity of the Earth connection).

Then fit a 10A slow-blow M205 fuse into the fuseholder in the IEC connector. Do not connect 230VAC power to the unit until you have done the set-up adjustments. All setup is done using the low-voltage supply only.

DO NOT CONNECT 230VAC power without the lid in

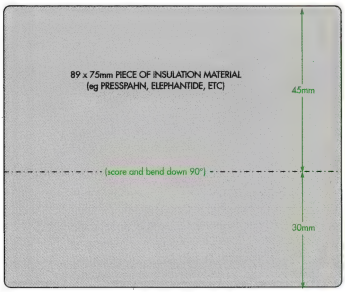


Fig.8: L-shaped insulation barrier inserted between the low voltage components and the mains wiring.

Parts List – TempMaster Mk3

1 Polycarbonate case, light grey, 115 x 90 x 55mm (Jaycar HB-6216 or similar)
1 PCB, code 21108141, 80 x 104mm
1 SPST relay, 30A contacts with 12V/100mA coil (Jaycar SY-4040 or similar)
1 2.1mm or 2.5mm concentric DC connector, PC-mounting, to suit plugpack (CON1)
1 3.5mm switched stereo socket, PC-mounting (CON2)
1 2-way terminal block, PC-mounting (CON3)
2 3-pin SIL header strip, PC-mounting (LK1, LK2)
2 3x2-pin DIL header strip, PC-mounting (LK3, LK4)
4 Jumper shunts
3 1mm diameter PCB terminal pins
1 IEC panel-mount mains socket with fuse (CON4)
1 Single 250VAC switched General Purpose Outlet (GPO)
1 10A M205 fuse cartridge, slow blow
1 105 x 75mm piece Presspahn insulation (Jaycar HG-9985)
4 M3 6mm machine screws, pan head
2 M4 10mm machine screws, pan head
2 M4 15mm machine screws, pan head
4 M4 hex nuts with flat & lockwashers
2 M3 10mm Nylon screws, pan head, with Nylon hex nuts
1 205mm length of 10A 3-core mains flex
1 60mm length of 10A brown mains wire
2 70mm lengths of medium duty insulated hookup wire
6 Nylon cable ties
2 6.8mm insulated female spade connectors for 1.2mm wire
5 4.8mm insulated female spade connectors for 1mm wire
1 3m length of 2-conductor ribbon cable
1 25 x 50 x 3mm aluminium sheet
1 30 x 10 x 1mm aluminium sheet
2 25mm lengths of 2.5mm heatshrink sleeving
1 30mm length of 5.0mm heatshrink sleeving
2 M3 9mm machine screws, countersink head
2 M3 hex nuts & star lockwashers
1 3.5mm mono jack plug

Semiconductors

1 LMC6482AIN dual CMOS op amp (IC1)
1 LP2950ACZ-5 micropower LDO regulator (REG1)
1 LM335Z temperature sensor (TS1)
1 BC327 PNP transistor (Q1)
1 16V 1W zener diode (ZD1)
1 3mm red LED (LED1)
2 1N4004 1A diodes (D1,D2)
2 1N4148 signal diodes (D3,D4)

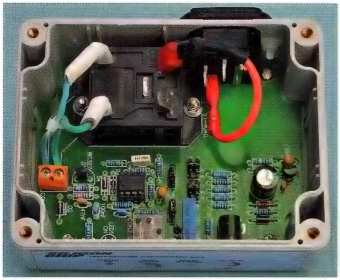
Capacitors

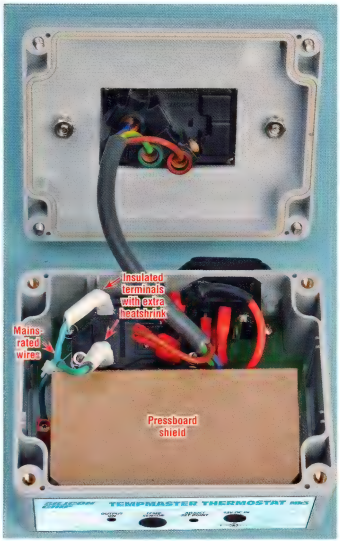
1 470µF 25V RB electrolytic
2 10µF 16V tag tantalum
1 1µF monolithic multilayer ceramic
1 100nF monolithic multilayer ceramic
1 47nF MKT
1 2.7nF MKT
1 1nF MKT

JAYCAR ELECTRONICS will release a 'short form' kit for the TempMaster Mk3 shortly – includes PCB with relay and onboard components plus temperature sensor and mounting plate. Cat KC-5529, $39.95

Resistors *(0.25W 1% unless specified)*

2 10MΩ 3 220kΩ 1 22kΩ 1 6.8kΩ 1 5.6kΩ 1 4.7kΩ
1 2.4kΩ 1 1.8kΩ 1 1.2kΩ 3 200Ω 2 100Ω
1 10Ω 0.5W 5%
1 500Ω horizontal 25-turn cermet trimpot (VR1)





Internal views of the TempMaster Mk3 – above, with the PCB in place and at right, fully assembled with shield.

place, to eliminate the risk of electric shock.

Setting it up

This is done by adjusting trimpot VR1 (using a small screwdriver through the access hole in the front panel) to produce the reference voltage level at test point TP1 corresponding to the average temperature you want the TempMaster to maintain.

First plug the 12V DC cable from your plug pack or battery supply into CON1 at the right-hand end of the box – do not plug the mains supply in yet. Then use your DMM to measure the DC voltage between TP1 and TPG.

The voltage should be somewhere between the maximum and minimum levels you have set using the links of LK3 and LK4. Select the temperature you want from the horizontal axis of the graph in Fig.2, and adjust VR1 to obtain the corresponding DC value on the vertical axis.

All that remains now is to mount the remote sensor inside the fridge or freezer cabinet, or inside the hothouse or seed germinating cabinet, attaching the sensor's heatsink plate to the side of the cabinet using two short lengths of 'gaffer' tape.

Then you can run its ribbon cable outside, holding it

Capacitor Codes

No	Value	µF Value	IEC Code	EIA Code
❑ 1	1µF	1µF	1000n	105
❑ 1	100nF	0.1µF	100n	104
❑ 1	47nF	0.047µF	47n	473
❑ 1	2.7nF	0.0027µF	2n7	272
❑ 1	1nF	0.001µF	1n	102

Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑ 2	10MΩ	brown black blue brown	brown black black green brown
❑ 3	220kΩ	red red yellow brown	red red black orange brown
❑ 1	22kΩ	red red orange brown	red red black red brown
❑ 1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑ 1	5.6kΩ	green blue red brown	green blue black brown brown
❑ 1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑ 1	2.4kΩ	red yellow red brown	red yellow black brown brown
❑ 1	1.8kΩ	brown grey red brown	brown grey black brown brown
❑ 1	1.2kΩ	brown red red brown	brown red black brown brown
❑ 3	200Ω	red black brown brown	red black black black brown
❑ 2	100Ω	brown black brown brown	brown black black black brown
❑ 1	10Ω	brown black black brown	brown black black gold brown

TempMaster Connection Options

These diagrams show three different ways that the TempMaster Mk3 can be connected up to control the temperature of a fridge, freezer or heater set-up.

Which one you use will depend on whether your fridge/freezer/heater operates from 230VAC or 12V DC, and also whether you will be running it from the AC mains or from a battery supply.

Option A shows the simplest arrangement, where a 230VAC fridge/freezer or heater is to be operated directly from the mains supply.

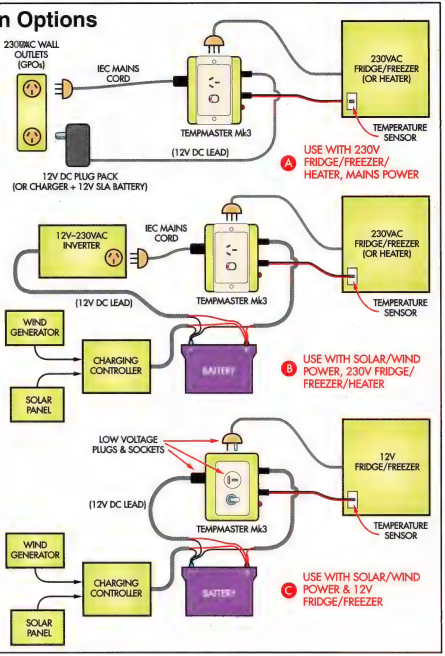
The 12V DC needed by the TempMaster itself can be supplied either by a small 'plug pack' DC supply or from a 12V SLA battery which is kept 'topped up' by a suitable charger.

Option B shows how a 230VAC fridge/freezer or heater can be connected to a 12V/230VAC power inverter, in a home or building which relies on solar or wind generated power.

The TempMaster itself can be powered from the main battery, along with the power inverter used to operate the fridge/freezer/heater.

Because there is no current whatever drawn from the TempMaster's IEC mains input socket when the TempMaster has switched off the power to the fridge/freezer/heater, the inverter should be able to drop back to 'sleep' mode at these times.

Option C shows how to connect things up when the TempMaster is to be used with a 12V fridge/freezer and a solar power system. In this case, you MUST replace both of the TempMaster's 'mains' connectors with suitable low voltage plugs and sockets, to make sure that they can't be accidentally connected to 230VAC.



down with further strips of gaffer tape so it will pass neatly under the rubber door seal when the door is closed.

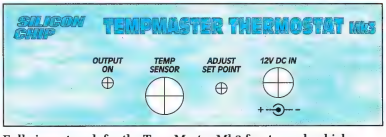
If you mount the thermostat case on the wall just behind the fridge/freezer or heater, the plug on the end of the ribbon cable can be plugged into CON2 on the lower front of the case to complete the job.

Now you can unplug the power cord of the fridge/freezer/heating cabinet from its original GPO socket and plug it instead into the GPO on the top of the TempMaster. Then when you connect the TempMaster's own IEC mains connector to the original GPO via a suitable IEC mains cable, the complete system will begin working. (You do have to flick the switch on the TempMaster's GPO to the 'on' position, of course!)

If you want to make sure that the thermostat is holding the fridge/freezer/heater to the temperature you want, this can be done quite easily using a thermometer placed inside the cabinet for a while.

You can see when the TempMaster is switching power to the compressor or heater simply by watching LED1.

If you need to adjust the average temperature up or down, this is done quite easily by adjusting trimpot VR1 using a small screwdriver, through the small hole in the front of the case (between the holes for CON1 and CON2). SC



Full-size artwork for the TempMaster Mk3 front panel, which mounts on the box side. The GPO fastens through the top of the box.

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Issue: August 2014

August Best Buys

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Bring 3D Prototyping to your desktop!

Manufactured in Europe by renowned kit maker Velleman, this superbly designed 3D printer allows you to create your own 3 dimension prototypes and designs at home. It features a 200 x 200 x 200mm build area with heated print bed and uses PLA or ABS 3mm filament. The tubular frame construction is simple to put together and leaves plenty of scope for modification if you so desire! • Excellent support from Velleman service forum • Fully upgradeable as new software & firmware is released. • Includes power supply • Includes ALL parts, no need to buy anything else. Build it and print! **Check the website for comprehensive specs.**

Optional Add Ons:
K 8230 Control module with LCD & SD card slot: **$149**
K 8234 LED lamp for a clear view of printed objects: **$34.95**

Filament Reels	Black	Grey	White	ONLY.
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X 2906

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2400W max. **P 8133**

$10 SAVE 30%
Shows real running costs of appliances

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A professional unit with advanced features such as true RMS AC measurement, resistance, temperature, capacitance, zero & hold functions - All supplied with carry case & test leads. Max input 600V.
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Flexibility of AC and DC testing!

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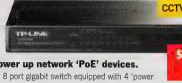

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An 8 port gigabit switch equipped with 4 'power over ethernet' (PoE) ports designed to power 802.3af compliant devices such as IP cameras, IP telephony handsets and wireless APs. Provides up to 15W of power per port up to 100m.

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This handy PoE adaptor allows you to convert an existing data only cable into a power & data cable run. This allows you to power 802.3af compliant devices such as IP cameras, IP telephony and wireless APs. Provides 15W over 100m.

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A slimline 3 coil charging pad for phones equipped with QI charging (or those fitted with a QI case). Just put your phone on the pad and it charges instantly!

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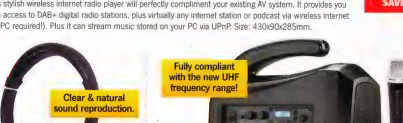
With remote control from your iOS or Android device.



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Address a crowd of up to 150 people without the need to shout - sets up instantly for use over the shoulder, or on a speaker stand. Provides 4 hours of use without the need for mains power! Excellent music & speech reproduction. Works with wired or UHF wireless mic. Weighs just 3.6kg! 153W x 246H x 333Lmm.

PA Models	Model	Normally	NOW.
Basic PA	C 7310	$450	$375
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Ask about our handy work stands to suit!

Super Bright Outdoor LED Floodlights.
This new range make great work lamps for renovators, or simply adding a light to the back of your ute or service van for when you need it! All metal construction, fully sealed and weatherproof.

Type	Part	ea.
10W 12V DC (115 x 135 x 84mm)	X 2310	$34.95
20W 12V DC (182 x 158 x 105mm)	X 2316	$59.95
50W 240V AC (288 x 238 x 150mm)	X 2318	$179

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Add peace of mind for your family with this range of PIR activated floodlights. Great for the driveway or backyard. All metal construction, with IP54 weather resistance. Must be connected to mains & installed by a licensed electrician.

Type	Part	ea.
10W 240V AC (115 x 135 x 84mm)	X 2340	$52.95
20W 240V AC (115 x 135 x 84mm)	X 2344	$86.95
50W 240V AC (182 x 158 x 105mm)	X 2346	$189

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Great party light!

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T 2630 Iron & Cartridge.

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125W Iroda Portable Gas Cartridge Tool
- Powered by refillable butane cartridge • Totally wireless operation - No need to run extension leads • Super tough design will last for years
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Ultra-bright long life LED for fantastic clarity (plus no need to change a globe - EVER!). Let "gadget" be your eyes. Identify those impossible to read miniature components. Great for stamp & coin collectors; model makers, jewellers etc. Fully adjustable ball joint head.

NO MORE EYE STRAIN!

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X 4204 3 Dioptre $49.95 TOP VALUE!

X 4205 5 Dioptre $55.95 TOP VALUE!

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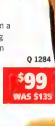

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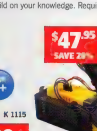

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Resistor-Capacitor Substitution Box

with parallel and series RC output

As any engineer, technician or advanced hobbyist will tell you, a resistance substitution box can save a lot of tears and angst. Same comments apply to a capacitance substitution box. Here's one that combines both resistance and capacitance in one box – and you can choose either resistance, capacitance or a combination of both – and that combination can be in series or parallel.

It often seems to be the case that you can never lay your hands on the particular resistor or capacitor you need.

You may be developing a new circuit, repairing an old one, tuning or tweaking equipment, testing test gear . . . whatever you're doing, circumstances will conspire to ensure that the one component you need is the one that you don't have.

That's when a resistance substitution box or capacitance substitution box can get you out of trouble.

Of course, it's not a permanent 'fix' – it's one that tells you what you need to buy at your next available opportunity.

The beauty of using a true resistance or capacitance substitution box is that the good ones give you a far greater choice of R or C than even discrete components do. So if your circuit needs, say, a 3,480Ω resistor, you can provide it.

You can also tell if a 3.3kΩ would do the job or if you need to go to a tighter tolerance. (Incidentally, you can get 3,480Ω in the E48 series or above).

In our April 2012 issue, Jim Rowe described a very handy Resistance Substitution Box, capable of 'dialling up' any one of a million resistance values between 10Ω and 10MΩ.

A couple of months later, in July 2012, Nicholas Vinen presented a Capacitance Substitution Box, which similarly allowed you to dial up virtually any capacitance between about 30pF and 6μF.

Altronics have taken this concept one step further again, with a combined Resistance AND Capacitance substution box. With a range of 1Ω to 999,999Ω and 100pF to 9.99999μF, it covers the vast majority of resistors and capacitors that you'd normally need in any service, development or troubleshooting work.

Both the resistance and capacitance sections of the box can be used independently via their own pairs of terminals but can also be connected in series or parallel by means of a 3-position slide switch.

The combined RC network is again brought out to another pair of terminals.

The result is a versatile RC box that is more useful than two separate boxes.

It's also smaller than our previous substitution boxes by dint of the use of a pair of six-way, ten-position thumbwheel switches to select the R or C value required.

It's mounted in a sealed ABS enclosure with an overall size of 145 x 105 x 65 (d) mm, with the top-mounted binding posts adding another 16mm.

Residual capacitance

You may be wondering why the minimum capacitance setting in this new box is 100pF when it's easy to get lower values, down to 1pF.

The reason is simple: residual capacitance. When everything is installed on the PCB, even with all care taken to minimise stray capacitance on the PCB, connecting wires, switches and terminals, the residual capacitance is bound to be a lot more than 1pF.

Hence, the residual capacitance in the box is about 20pF.

You will need to mentally add this value to any low value of capacitance you select, up to about 500pF; above that, the difference is likely to be swamped by the 10% tolerance of the switched capacitors.

Residual resistance

Similarly, although the lowest selectable resistance value is 1Ω, the residual resistance in the switches, terminals, PCB tracks and interconnecting wiring amounts to about 1.3Ω.

Decade

Article By ROSS TESTER

If that sounds like a lot, consider that there are six thumbwheel switches, one slide switch and umpteen solder connections to the wiring in the Resistance Selection and you can see that just a few milliohms in each connection can easily add up to one ohm or more.

So again, when you are selecting low resistance values, you will need to mentally add 1.3Ω to any value below about 100Ω.

Above that value, the 1% tolerance of the switched resistors becomes a dominant factor in the actual resistance value.

The circuit

The full circuit of this Resistance & Capacitance Substitution Box is shown in Fig.1 overleaf.

It basically consists of six switched banks of resistors and capacitors. The resistance and capacitance sides of the box are independent of each other until specifically connected together by the 3-position slide switch S1.

First of all, we'll look at the resistance side. The box works by switching resistors in series. Each switch position adds in another resistor.

Because there are ten positions on each thumbwheel switch, they're called 'decade' switches – they switch in the sequence 1, 2, 3, 4, 5 etc.

So on switch one, position one you'd have one ohm between the resistance terminals; position two switches in another one ohm resistor for two ohms, position three yet another for three ohms, and so on.

This is repeated with the other five switches which, in turn, work with 10Ω, 100Ω, 1kΩ, 10kΩ and 100kΩ resistors.

So with all switches in position '9', you would have 9 x 100kΩ (900kΩ) plus 9 x 10kΩ (90kΩ) plus 9 x 1kΩ (9kΩ) plus 9 x 100Ω (900Ω) plus 9 x 10Ω (90Ω) and 9 x 1Ω (9Ω), all in series. Add those all up and you have 999,999Ω (plus the 1.3Ω of residual resistance, of course).

The resistance set by the thumbwheel switches is made available at the top set of red and black terminals.

This truth table shows how the binary-coded-decimal switch brings in the capacitors connected to the 1, 2, 4 & 8 terminals. Position 5, for example, connects the capacitors on terminals 1 and 4.

DEC	8	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Capacitance Switching

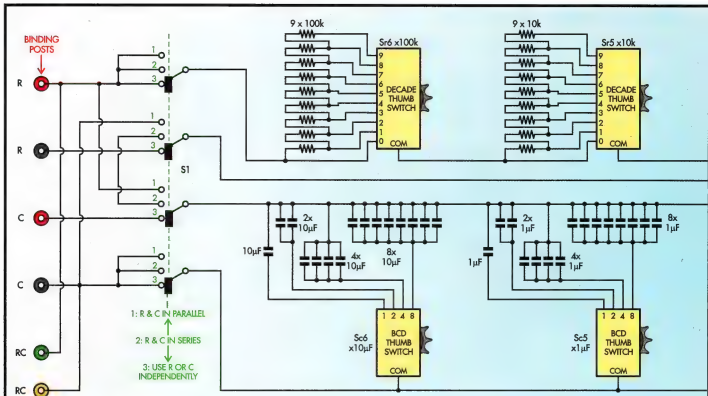
Capacitance selection is done a little differently, using binary-coded decimal (BCD) switches to achieve a similar result with fewer components, saving both space and money (larger capacitors tend to cost more!).

And remember that we are switching capacitors in parallel (not series, as with resistors) to obtain larger and larger capacitances.

Connected to the 1, 2, 4 & 8 terminals of the BCD switches are a combination of parallel-connected capacitors.

Looking at the '100pF' switch, a 100pF connects to the '1' terminal, a pair of 100pF (ie, 200pF) connect to the '2' terminal, a 180pF and 220pF (ie, 400pF) connect to the '4' terminal while a 330pF and 470pF (ie, 800pF) connect to the '8' terminal.

Now the BCD coding comes into play. Have a look at the BCD 'truth



table' above. In this, '0' means no connection while '1' means a connection. This is all arranged by switch contacts within the BCD switch.

Remember that capacitors in parallel add together, so with the '100pF' switch in positions 1 or 2, you get 100pF and 200pF, respectively. In position 3, the switch connects terminals 1 and 2 together, to give you 300pF. In position 4, you get 400pF, position 5 connects terminals 4 and 1 together to get 500pF, position 6 connects terminals 4 and 2 together (600pF) while 7 connects 4, 2 and 1 together (700pF). Position 8 has only the 800pF connected to it while position 9 connects 8 and 1 to give 900pF.

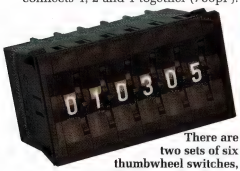
The second, or x1nF switch, has slightly different values but they equate to the same thing – 1nF on terminal 1, 2nF on terminal 2, 4nF on terminal 4 and 8nF on terminal 8. Similarly, the third, or x10nF switch, with the 1, 2, 4 & 8 units.

The end result is the same – a maximum of 9.99999µF at the Capacitance (centre) terminals when all capacitance switches are in the '9' position (not forgetting the residual capacitance that we mentioned).

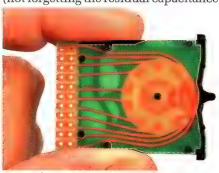
Series/parallel RC

The 3-position slide switch S1 connects the resistance and capacitance sections in series or parallel and the resultant RC network is connected to the third set of terminals, coloured green and yellow to distinguish them from the R and C terminals.

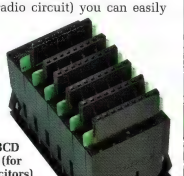
So if you're working on a project (or perhaps repairing a device) which uses an RC time constant (such as a timer, frequency generator, filter or even a radio circuit) you can easily



There are two sets of six thumbwheel switches, one set of BCD switches for the capacitors, the other a decade set for the resistors. The six switches click together and are held in position by end plates, as shown here.



Here's how to tell the switches apart: on the decade switch PCB, each switch position has a single track brought out to the rear connector. The BCD switch has a more intricate PCB track pattern.



The six BCD switches (for the capacitors) each have a 9-way header socket attached (only five pins are actually used). The capacitor PCBs plug into these sockets.

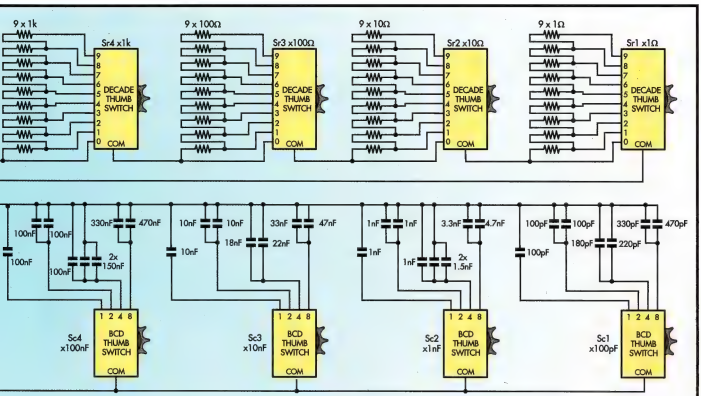


Fig.1: the circuit consists of the various thumbwheel switches bringing resistors and capacitors into circuit. At left, a 3-position slide switch allows series, parallel or independent connection.

achieve this by setting the R and C to their appropriate values and moving the slider switch to either the series or parallel position, depending on the circuit requirements.

Here's where one of the really handy features of this RC box emerges: if the time constant or frequency is not exactly what you're after, it's simply a matter of turning the thumbwheel switches to achieve the desired result.

No more unsoldering and resoldering components . . . just dial up and go!

When you have got exactly what you need, simply read the values of R and C from the switches, select the same value components and finish/repair/calibrate/etc your project!

As you can see, an RC box is a pretty handy device to keep on your workbench or service toolbox – and this one is the handiest we've seen.

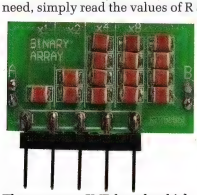
Construction

First step is to assemble the two thumbwheel switch sets. They look quite similar, so make sure they're not mixed up – the BCD switches have five terminals, while the decade switches have ten.

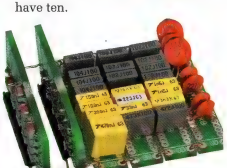
There are seven small PCBs used in this project, six of which hold the various capacitors and attach to the back of the BCD switch bank.

Four of these seven are identical and hold the through-hole capacitors. The other two boards, also identical, hold the 1µF and 10µF capacitors which are all surface-mount devices (SMDs). If you're wondering why SMDs were used on these boards, it's because through-hole versions simply wouldn't fit – apart from the fact that they cost more!

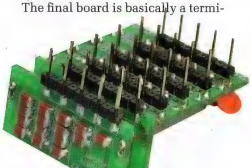
The final board is basically a termi-



There are two SMD boards which hold the larger value capacitors. All of the capacitors are identical on their respective PCBs.



Four PCBs hold the through-hole capacitors and are mounted side-by-side. Use this photo as a guide to capacitor placement.



And here's the view from the opposite side, showing the six header pin sets underneath which plug into the BCD thumbwheel switches.

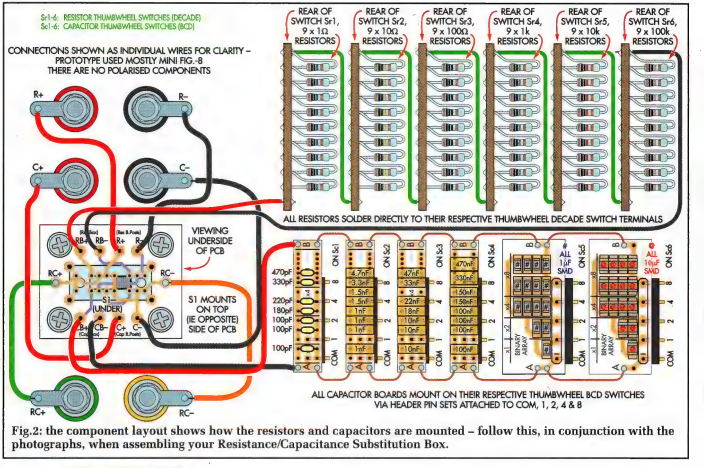
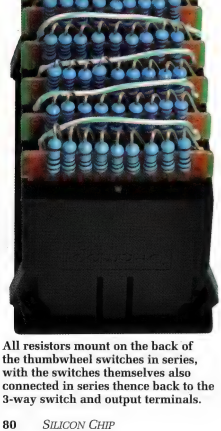


Fig.2: the component layout shows how the resistors and capacitors are mounted – follow this, in conjunction with the photographs, when assembling your Resistance/Capacitance Substitution Box.



All resistors mount on the back of the thumbwheel switches in series, with the switches themselves also connected in series thence back to the 3-way switch and output terminals.

nation point for the slider switch pins (which mounts on it) plus the various flying leads to the other PCBs and to the six terminals.

The resistors (and there are 54 of them!) all mount directly to the terminals of the decade switch bank (these terminals are actually small PCBs but we haven't counted them as they are part of the switches). Nine 1Ω resistors mount on the first switch, nine 10Ω on the second and so on up to the nine 100kΩ on the sixth bank.

This is quite fiddly work as the nine resistors all solder in a tight parallel arrangement, with one lead soldered to the switch contact and its other lead crossing over to the next switch contact. The wrinkle here is that the next resistor in the string also has one lead soldered to the same pad, so you have to ensure that you don't unsolder one as you solder the other!

Our close-up photo at left shows the resistor thumbwheel completely assembled so you can see what we mean.

Once you get the hang of it, it's not that difficult – just tedious. One down, 53 to go. Two down, 52 to go. . .

These boards are all connected in series: each of the six 'finish' terminals connects, via a short length of hookup wire, to the 'start' terminal on the next switch. The 'start' terminal of switch one and the 'finish' terminal of switch six connect back to the main termination PCB mentioned earlier (and which we'll come to shortly).

Capacitors

As we mentioned earlier, two different types of PCBs hold the capacitors. There are four which secure to the BCD switches 1-4 (100pF, 1nF, 10nF, 100nF) and hold traditional (ie, through hole) capacitors from 100pF to 470nF. The final two boards (1μF and 10μF) are for SMD (surface-mount device) 1μF and 10μF capacitors.

The four boards mount horizontally while the other two (ie, the 10μF and 1μF boards) mount vertically. The main reason that different boards are used for the larger-value capacitors is that through-hole components over 1μF (and especially the 10μF) are too large to mount on the boards so they can fit on the switches.

Once again, assembly isn't too difficult but is complicated a little by the use of SMDs. However, these devices are being used more and more these

days (in fact, many components are no longer available in through-hole) so you'd better get used to them!

For more detail on the use and soldering of SMDs, refer to the articles on the subject in the March 2008 and December 2010 issues – both available online at siliconchip.com.au

Fortunately, all SMDs on each board are identical – there are 15 1µF capacitors on the 1µF switch board and 15 10µF capacitors on the 10µF switch board. Just don't get the 1µF and 10µF types mixed up because they do look similar although the 10µF capacitors are somewhat larger. SMD capacitors normally do not come with any markings.

Speaking of mixups, the other four boards are not quite so simple because there is some difference in the component position, not to mention that the component values are all different. Take your time and refer to both the photographs and to the component overlay diagrams.

Unlike the resistance PCBs, all six of the capacitance PCBs connect in parallel – all the 'A' terminals are connected together, as are all the 'B' terminals. The four horizontal boards are connected with short loops of tinned copper wire – the offcuts from the resistor leads are ideal. They should be butted up to each other.

The two vertical-mounting boards have short lengths of tinned copper wire which connect the two boards together (A to A and B to B) and then 'jump across' to join onto the A and B positions on the horizontal boards. The close-up photo will show this more clearly.

All six boards 'plug in' to header sockets which in turn plug in to mating pins on their respective BCD rotary thumbswitches – connecting COM to COM, 1 to 1, 2 to 2, 4 to 4 and 8 to 8.

The only "component" on the terminal board is the 3-way switch. All other points connect to the thumbwheels or terminals.

Parts List – Resistor-Capacitor Substitution Box

1 Termination/Switch PCB, Coded K7520A, 28 x 35mm (Altronics)
4 Through-hole capacitor PCBs, Coded K7520B, 35 x 8mm (Altronics)
2 SMD Capacitor PCBs, Coded K7520C, 35 x 16mm (Altronics)
1 ABS Case, 145 x 195 x 65mm, punched and printed (Altronics Cat H0307/K7520)
6 Thumbwheel decade switches (0-9) (Altronics Cat S3302)
6 Thumbwheel BCD switches (0-9) (Altronics Cat S3300)
2 Pairs end caps for thumbwheel switches (Altronics Cat S3305)
1 4-pole, 3-position slider switch (Altronics Cat S2033)
2 40-way pin headers (Altronics Cat P5430)
2 Header pin sockets, 40 pin, 90° (Altronics Cat P5392)
8 Machine screws, M3 x 6mm
4 M3 threaded stand-offs, 12mm
1m hookup wire (or mini fig-8)
Tinned copper wire (if required)
2 short lengths (~50mm) ribbon cable

Capacitors	CODES:	µF Value	IEC Code	EIA Code
15 10µF 50V SMD		10µF	10µ	106
15 1µF 50V SMD		1µF	1µ0	105
1 470nF 100V MKT		0.47	470n	474
1 330nF 100V MKT		0.33	330n	334
2 150nF 100V MKT		0.15	150n	154
4 100nF 100V MKT		0.1	100n	104
1 47nF 100V MKT		0.047	47n	473
1 33nF 100V MKT		0.033	33n	333
1 22nF 100V MKT		0.022	22n	223
1 18nF 100V MKT		0.018	18n	183
3 10nF 100V MKT		0.010	10n	103
1 4.7nF 100V MKT		0.0047	4n7	472
1 3.3nF 100V MKT		0.0033	3n3	332
2 1.5nF 100V MKT		0.0015	1n5	152
4 1nF 100V MKT		0.001	1n0	102
1 470pF 50V ceramic		–	470p	471
1 330pF 50V ceramic		–	330p	331
1 220pF 50V ceramic		–	220p	221
1 180pF 50V ceramic		–	180p	181
3 100pF 50V ceramic		–	100p	101

Resistors (1% metal film, 0.6W)

9 100kΩ	*(Code brown black black orange brown)*	NOTE: only 1% (5 band) or better resistors should be used for this project to avoid errors.
9 10kΩ	*(Code brown black black red brown)*	
9 1kΩ	*(Code brown black black brown brown)*	
9 100Ω	*(Code brown black black black brown)*	
9 10Ω	*(Code brown black black gold brown)*	
9 1Ω	*(Code brown black black silver brown)*	

Termination Board

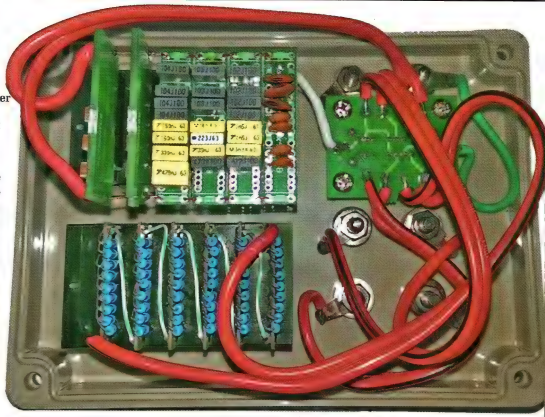
This PCB not only provides an anchor point for the wires coming from the resistance and capacitance board assemblies and going to the six binding posts (terminals), it also provides a mounting point for the two-way, three-position switch which selects between isolated R & C, series R & C or parallel R & C

The switch mounts on the conventional side of the board (it will only go in one way) and the board then mounts upside-down on four 12mm pillars via 6mm M3 screws.

This method enables the switch actuator to poke through the front panel at the right height.

The various wires (ten of them, or five lengths of Fig.8) solder to the exposed copper side of the PCB.

Using the photos as a length guide, cut the wires to appropriate lengths, bare and tin both ends and solder the



Finally, here's the completed project, all mounted inside the lid of the case. It has the capacitor switching at top left, resistor switching at lower left, through/parallel/series switch on its PCB at top right and the terminals down the right side.

six solder lugs (which came with the binding posts) to one end. Fit the binding posts to their respective wires.

The opposite ends are now soldered to the PCB – make sure you get the right ones in the right place.

The remaining four wires (or two Figure-8s) solder to the 'A' and 'B' positions on the resistance and capacitance boards, as per the layout diagram and photos.

The case

If you're putting this together from the Altronics kit (K7520) it will come with the case already punched and drilled for the thumbwheel switches, parallel/series switch, binding posts and screws – and the top of the case will also be printed, as per our photos.

Checking it out

Give your project the once-over, checking for bad solder joints, misplaced components, etc.

Checking the individual 'R' and 'C' functions is delightfully easy: switch the series/parallel switch to 'off' (ie, fully left) and connect your multimeter on the appropriate range (R or C) to the appropriate substitution box terminals (R or C) and switch through the ranges with the thumbwheels.

Apart from the '000000' settings (or even very low ohms or capacitance), you should find the multimeter reads the same, or at least quite close to, as what your thumbwheels say – otherwise, you've got a problem!

If you get no reading at all, it's almost certainly an open circuit/dry joint in your soldering; if you get strange readings, it's more than likely mixed-up components.

As mentoned earlier, with all switches set to zero (on both R & C) it is normal to obtain very low readings – perhaps an ohm or so on resistance and maybe 20pF or so on capacitance. Residual C and R should always be taken into account when working with low settings.

This applies to all RC substitution boxes, certainly not just this one!

Checking the series or parallel RC is not quite so simple – probably the easiest way is to use a moving coil multimeter, set the RC Box to parallel and with your multimeter already connected to the binding posts and on its lowest DC value, switch the RC box to the highest R&C settings.

You should see the voltage rise fairly quickly as the multimeter itself charges the capacitor.

Change the box resistance to a much lower value and the voltage should rise much more quickly. If it does, you can be fairly confident that it's working as it should.

Of course, advanced hobbyists, technicians or engineers would have much better ways to check this function but if you don't have advanced equipment, you don't have it! SC

Where from, how much?

This project was designed by Altronics Distributors, who retain the copyright on the PCBs. Complete kits are available from Altronics stores, resellers and via www.altronics.com.au for $119.95 plus p&p. (Cat K7520) This includes the pre-printed and punched case.

PRODUCT SHOWCASE

Sydney Mini Maker Faire®

Returning to the Powerhouse Museum, Sydney, for its second year as part of the opening weekend of Sydney Design 2014, the Sydney Mini Maker Faire is on Saturday 16 to Sunday 17 August.

Maker Faire is a family-friendly showcase of invention, creativity and resourcefulness, and a celebration of the world-wide Maker movement, a place where people show what they are making and share what they are learning.

Maker Faires are primarily designed to be forward-looking, showcasing Makers who are exploring new forms and new technologies. But it's not just for the novel in technical fields; Maker Faire features innovation and experimentation across the spectrum of science, engineering, art, performance and craft.

Contact:
Sydney Mini Maker Faire
(@ Powerhouse Museum: 500 Harris St Ultimo)
Tel (Maker Faire): (02) 9217 0370
Website: www.makerfairesydney.com

Arduino-Programmable IR Webserver

The KTA-294 IR Webserver from Ocean Controls has primarily been designed to allow IR controlled Air Conditioning units to be controlled via a mobile internet enabled device. The IR Webserver can learn up to seven IR commands and transmit them on request via a web page interface, as well as displaying two temperatures from sensors, primarily intended for indoor and outdoor temperature display.

Though designed for Air Conditioning units, the device is not restricted to them and can learn IR commands with different protocols. A list of tested devices is included with notes.

Source code for the IR Webserver is provided and can be modified by the user to work with a particular IR protocol.

To enable control from outside a home network port forwarding must be enabled on the WAN router.

Contact:
Ocean Controls
Factory 3/24 Wise Ave, Seaford Vic 3198
Tel: (03) 9782 5882
Website: www.oceancontrols.com.au

THE MUST-HAVE REFERENCE BOOK FOR EVERY WORKSHOP OR SHED

This 324 page technical book covers all you need to know about anything you need to do in your workshop with in-depth detailed explanations and step-by-step illustrations on many activities.

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This is definitely not a book you read once; it's a book you pick up and refer to when needing help or suggestions in pointing out hidden traps to look out for in that particular topic you want to know about.

There are 64 categories covering workshop setups, tools, measuring, fasteners, metal and wood working, welding, machining and plenty more,

The price is only $39.00, available from all Hare & Forbes Machineryhouse branches – Sydney, Melbourne, Brisbane and Perth.

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Tel: (02) 9890 9111
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Control, locate and protect objects

KCS Trace-ME GPRS/GPS Modules enable you to remotely track and trace a variety of objects, from small packages to cars, trucks, containers or ships. Its small, lightweight aluminium design makes it easy to install and together with the extended position logging, it's ideal for use in fleet management, anti-theft and M^2M applications.

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13 Mons School Rd, Mons Qld 4556
Fax: (07) 3319 7302
Website: www.kcs-trade.com.au

Precise BroadR-Reach interface verification with R&S RTO oscilloscopes from Rohde & Schwarz

Rohde & Schwarz has expanded the application field of the R&S RTO oscilloscopes to include the testing of automotive Ethernet interfaces. In line with the OPEN Alliance test specification, the new R&S RTO-K24 compliance test software enables users to perform automated tests on BroadR-Reach Ethernet interfaces.

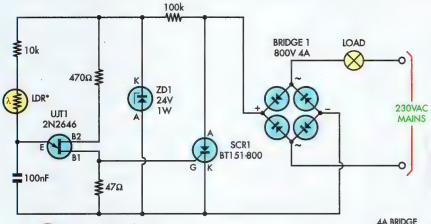
BroadR-Reach technology makes it possible to combine multiple applications such as video streaming from rear view cameras and signal transmission from automotive radar systems to create a single, open and scalable Ethernet network inside the vehicle.

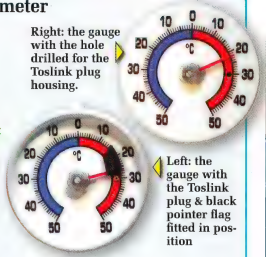
Contact:
Rohde & Schwarz (Aust) Pty Ltd
Unit 2, 75 Epping Rd, North Ryde NSW 2113
Tel: (02) 8874 5103 **Fax:** (02) 8874 5199
Website: www.rohde-schwarz.com.au

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Temperature control with a fridge/freezer thermometer





Right: the gauge with the hole drilled for the Toslink plug housing.

Left: the gauge with the Toslink plug & black pointer flag fitted in position

When growing seedlings under LED lights a heater may be required in cold weather to maintain the optimum temperature of 30°C, with a range of 27-32°C. In the humid conditions inside a growbox, a mechanical temperature sensor is more reliable so a cheap fridge/freezer dial thermometer from eBay was used. This reads temperatures up to 50°C, so it is quite suitable for this purpose.

The front cover is removed from the dial and a 2.4mm or 2.5mm hole drilled at the 30°C point. This hole should be small enough for the ferrule of a Toslink cable to be a tight push-fit. Then a small black plastic 'flag' (a piece of heatshrink tube) is glued on the pointer with Superglue. The other end of the Toslink cable shines on a mini LDR. This LDR can be fitted inside a Toslink socket housing if the transmitter/sensor is removed.

When the thermometer is positioned under the LED light, the black flag will stop light from entering the Toslink cable when the temperature reaches 30°C. In fact, it will not be an abrupt on/off process and the pointer flag will more gradually block the hole until the light is completely cut off.

This action is used to control the resistance of the LDR (at the other end of the Toslink cable) in the accompanying phase-controlled SCR circuit. The change of resistance of the LDR alters the time constant which controls the triggering of the unijunction oscillator. Each time the unijunction is triggered it delivers a pulse to the gate of the SCR, turning it on for one half-cycle of the 50Hz. In practice, the SCR is turned on for progressively larger portions of each 50Hz half-cycle as the pointer flag covers more of the LDR.

The incandescent lamp or resistive heater load is connected in series with the mains voltage via a bridge rectifier. The complete circuit including the Toslink socket with the LDR can be installed in a small plastic project box which is outside the growbox. **Note that all parts (including the LDR) operate at mains potential and must be fully enclosed in the plastic case.**

For larger lamp or heater loads, use a higher-rated diode bridge and mount the SCR on a suitable heatsink. If you do not wish to occlude the LED lights, a light-pipe, second Toslink cable or separate single LED can be fitted over the thermometer to illuminate the region around the 30°C mark.

John Russull,
Tottenham, UK. ($45)

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As you can see, we pay $$$ for contributions to Circuit Notebook. Each month the BEST contribution *(at the sole discretion of the editor)* receives a **$150 gift voucher from Hare&Forbes Machineryhouse**. That's yours to spend at Hare&Forbes Machineryhouse as you see fit - buy some tools you've always wanted, or put it towards that big purchase you've never been able to afford!

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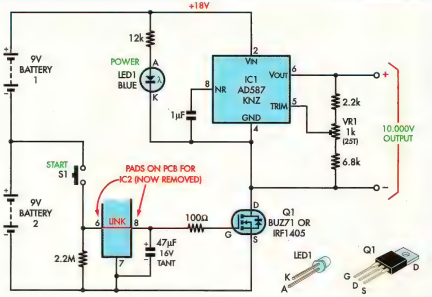
Simplified 10V Precision Voltage Reference

Not long after the 10V Precision Voltage Reference Mk2 was published in the March 2014 issue of SILICON CHIP we received emails from several readers, complaining about higher than expected current drain causing one of the batteries to go flat prematurely. This was because the timing oscillator in the 4541B digital timing chip continues to run even when the chip has not been triggered, drawing a current of around 1mA from the lower 9V battery even when the device is nominally 'off'.

This drawback is not apparent from the 4514B data sheet (as far as we could see) and we tried a number of measures to to disable the timing oscillator when the chip is in the triggered state; none were successful.

Ultimately, we have solved the problem by removing the 4514B and its associated timing components and using an RC network to provide



the timing period for Mosfet Q1. Pins 6 & 8 of the vacant IC2 are bridged and a 47µF tantalum capacitor is connected between pins 7 & 8, and a 2.2MΩ resistor is connected between pin 6 and the 0V line.

The resistor and capacitor then form an RC time-delay circuit which keeps Mosfet Q1 biased 'on' for about 110 seconds after pushbutton switch S1 (Start) is released. The timing may not be a precise as provided by the 4514B originally used but it does have the merit of zero current consumption when Mosfet Q1 turns off.

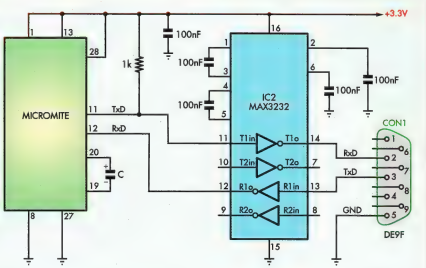
Jim Rowe,
SILICON CHIP.

RS232-to-TTL serial interface for the Micromite

As described in recent issues of SILICON CHIP, the Micromite is a truly powerful embedded microcontroller running MMBasic. However, when using Tera Term to communicate with the Micromite you need a USB-to-TTL serial converter between the PC and the Micromite.

This works well but the converter is quite expensive if purchased locally. If you have an older computer which has an RS232 output (eg, the COM1 port), you can fashion an RS232-to-TTL converter and use the COM1 port to communicate with the Micromite.

The original article warns against using the RS232 port to connect directly to the Micromite. This is because the voltage levels and signal polarity are incorrect. The article indicates that a converter must be used. This item describes a simple converter which provides TTL signals with the correct voltage and polarity.



A MAX3232 chip and a few 100nF capacitors are all that are required. The diagram shows the RS232 TX and RX lines being converted to and from the Micromite TTL levels. Since the MAX3232 is powered from the same 3.3V supply as the Micromite, there is no mismatch in the TTL levels of the converter and the Micromite.

The converter needs no setting up and there are no drivers to install. When Tera Term is run, it automatically finds COM1. In the Tera Term SETUP menu, just configure COM1 to 38,400 baud, 8 bits, no parity and one stop bit, as detailed in the May 2014 article.

Jack Holliday,
Nathan, Qld. ($35)

MISS THIS ONE?

Published in Dec 2012

2.5GHz 12-digit Frequency Counter

with add-on GPS accuracy

Wow! 10Hz - >2.5GHz in two ranges; 1us - 999,999s with a 12-digit LED display. It's a world beater and it's the perfect addition to any serious hobbyist's bench – or the professional engineer, technician, in fact anyone who is into electronics! You'll find it one of the handiest pieces of test gear you could ever own and you can build it yourself.

All the hard-to-get bits (PCBs, micros, LEDs, panels, etc) are available from the SILICON CHIP PartShop.

You'll find the construction details at http://siliconchip.com.au/project/2.5ghz
PCBs, micro etc available from PartShop

Where do you get those HARD-TO-GET PARTS?

Many of the components used in SILICON CHIP projects are cutting-edge technology and not worth your normal parts suppliers either sourcing or stocking in relatively low quantities.

Where we can, the SILICON CHIP PartShop stocks those hard-to-get parts, along with PC boards, programmed micros, panels and all the other bits and pieces to enable you to complete your SILICON CHIP project.

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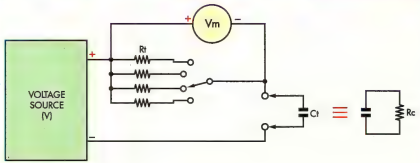


Simple measurement of capacitor leakage resistance

Measuring DC leakage resistance of electrolytic capacitors can be difficult due to the long charge times and the high impedances involved. DC leakage resistance becomes critical in high-impedance circuits where long RC time constants are required. This circuit is a simple method for roughly measuring high resistances.

Briefly, it connects a DC supply in series with switched resistors (R_t) and the capacitor (C_t) to be tested. A multimeter measures the voltage across resistor R_t and when the measured voltage, V_m, has stabilised, the DC resistance of the capacitor is given by:

$$R_c = R_t (V \div V_m - 1) \approx R_t V \div V_m$$ since for any decent capacitor (and R_t value) V >> Vm.

As an example, if V = 10V, V_m = 0.001 and Rt = 10kΩ, then Rc ≈ 100MΩ. If better accuracy is required then a known large value resistor can be used to calibrate the circuit. Any voltage source, V, can be used, provided it is less than the rated voltage of the capacitor under test.

Switched resistors, Rt, are a set of small to large resistances, the small resistors being useful to rapidly charge the capacitor under test. V_m is the voltage measured across resistor R_t. C_t, the capacitor under test, can be considered as an equivalent capacitor and resistor, R_c, in series.

The set of resistors, R_t, can be chosen to give different convenient ranges for the meter measurement, V_m, but should be small enough so that the meter's resistance and resultant shunt current (typically 10MΩ for a digital multimeter) is not significant. One of these resistors should be small to rapidly charge large capacitors, eg, 1kΩ.

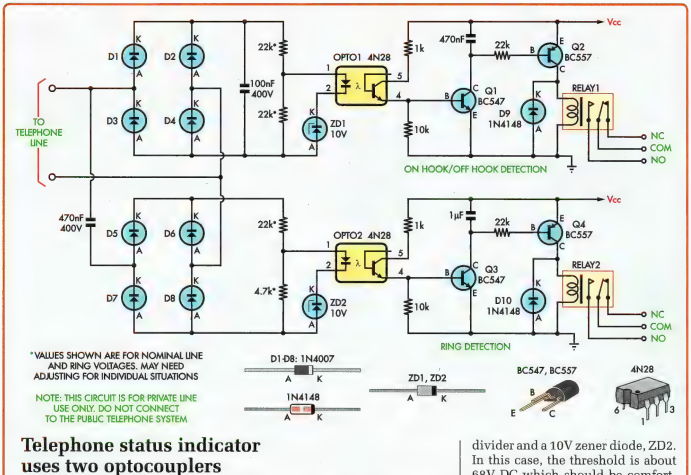
The accompanying table (Table 1) shows some results obtained from a number of non-polarised capacitors from different manufacturers. Polarised electrolytic capacitors tend to have higher resistances.

Note that even with rapid charging of the capacitors, it can take a while for the voltage, V_m, to stabilise.

Alan Wilson,
Glen Iris, Vic. ($40)

Table 1: Example Results

Capacitor	Measured Voltage	Leakage Resistance
3.3µF polyester	<0.1mV	>1000MΩ
50V 6.8µF bipolar	0.8mV	~125MΩ
50V 10µF bipolar	5mV	~20MΩ
50V 10µF bipolar	1.8mV	~55MΩ
50V 22µF bipolar	14mV	~7.1MΩ



Telephone status indicator uses two optocouplers

This circuit is intended to detect both the RING and ON/OFF HOOK status of a telephone line. In essence, it has two bridge rectifiers connected in parallel across the incoming telephone line. The top bridge rectifier (D1-D4) is for On-hook/Off-hook detection and senses the DC voltage across the line. The DC voltage from the bridge rectifier is filtered with a 100nF capacitor and fed to a optocoupler OPTO1 via a voltage divider consisting of two 22kΩ resistors.

OPTO1 is connected in series with a 10V zener diode, ZD1. The resulting voltage must be sufficient to cause the infrared LED inside the optocoupler to light. This indicates that the phone is on-hook, ie, not in use. OPTO1 drives transistors Q1 & Q2 and these in turn drive Relay1.

The resistors and diodes in the circuit mean that the telephone line voltage must be more than about 24V DC to indicate the on-hook condition. Typically, when the phone is off-hook (ie, being used), the line voltage will be less than 8V and so OPTO1 and Relay1 will not be enabled.

The second bridge rectifier (D5-D8) is coupled to the phone line via a 470nF capacitor which means that it will only respond to the pulsed AC ring signal which can be 60VAC or more. The rectifier's output voltage is coupled to OPTO2 via a resistive divider and a 10V zener diode, ZD2. In this case, the threshold is about 68V DC which should be comfortably exceeded by peak voltage of a typical ring signal.

The 1µF capacitor at the base of Q4 ensures that a typical ring signal will not cause Relay2 to judder but merely close when a ring signal is present.

The supply voltage (Vcc) should be between 9-14V DC, to suit 12V relays.

Mark O'Farrell,
MacQuarie Fields, NSW. ($40)

Editor's Comment: this circuit should be used on private telephone lines only. Readers should note that it is illegal to connect a non-approved device to the public telephone system.

Atlas DCA75 Pro Semiconductor Analyser

Review by NICHOLAS VINEN

This is the latest and greatest version of PEAK's popular analyser and has been improved in several important ways. It now has a larger graphical LCD display, to show more information at one time and a USB interface which allows a PC running the supplied software to plot various curves for semiconductor devices.

The new Atlas DCA75 is the same size, shape and weight as the old DCA55 but it has significantly enhanced capabilities.

In case you are not familiar with this series of Semiconductor Analysers, essentially what they do is, in seconds, identify the type and pinout of just about any two or 3-pin semiconductor device.

For the new DCA75, that includes bipolar transistors, Darlingtons, Mosfets, IGBTs, JFETs, diodes, diode networks, LEDs, zeners, SCRs, Triacs and voltage regulators.

It also gives some basic parameters for the device such as forward voltage, gain, V_{BE}, gate threshold, voltage, leakage current and so on (depending on the type of device being analysed). If the device is faulty, such as having a short between two of the pins, the Semiconductor Analyser will tell you so.

This type of device is certainly handy for servicing equipment since it lets you identify unknown or unmarked components (once they have been removed from circuit) and it also lets you check known types of semiconductors to see whether they are still functional and also whether their critical parameters are within specifications.

Importantly, the order in which leads are connected to terminals does not matter, so it works well on unknown devices but also saves you the bother of having to look up the pin-out of known devices before hooking it up. The

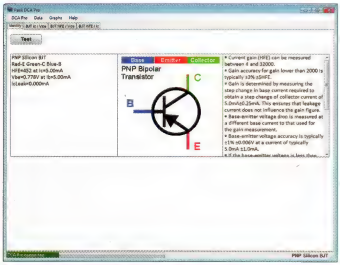


Fig.1: with the DCA75 connected to USB, you can identify and measure components from your PC just like you would with the unit operating in standalone mode but the results are all visible at a glance.

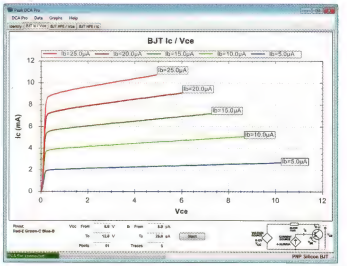
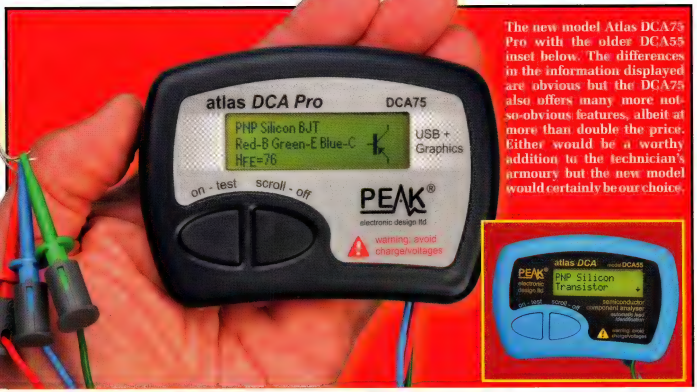


Fig.2: the USB connection also allows graph plotting, which can't be done otherwise. There are various curves for different semis, in this case we plotted V_{CE} against collector & base current for a bipolar junction transistor.



The new model Atlas DCA75 Pro with the older DCA55 inset below. The differences in the information displayed are obvious but the DCA75 also offers many more not-so-obvious features, albeit at more than double the price. Either would be a worthy addition to the technician's armoury but the new model would certainly be our choice.

leads are colour coded and once the type of component has been detected, the unit indicates which colour lead connects to which terminal so you can see the correct pin-out at a glance.

This type of device is also useful while developing and building electronic devices as it lets you not only check that the components you are fitting are fully functional but also helps to choose matched devices, if your application needs them. For example, this would be useful for matching output transistors in an audio amplifier or input transistors in a very precise test instrument.

Having said that, the DCA Pro has some limitations, largely due to the fact that it is small, light and battery-powered. When testing a semiconductor, after having identified it, it applies test voltages and currents to the various pins in order to analyse the device's behaviour. But it can only really apply voltages up to 10-12V and currents up to about 10mA (depending on the test voltage), so can only characterise a limited range of the performance of high-current, high-voltage parts.

Improvements

This new Analyser can do everything the old one could do and more.

For a start, it uses one standard AAA cell rather than a 12V battery, so you're more likely to have a replacement around

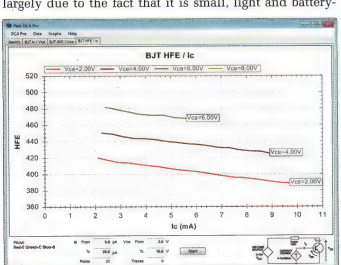


Fig.3: another plot availble for bipolar transistors, this shows gain versus collector current at varying collector voltages. This is a good way to check a transistor's small signal linearity.

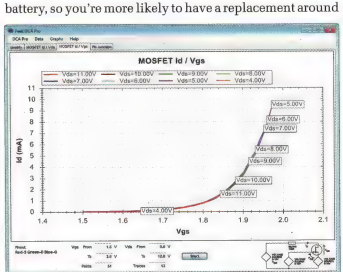


Fig.4: plots available for Mosfets are naturally different from those with bipolar transistors. This shows drain current plotted against gate voltage for various drain voltages, indicating the switch-on threshold.

if it needs a fresh one (and AAAs are a lot cheaper, too!).

The graphical display not only allows the unit to display the circuit symbol of the device under test but also makes it much easier to read off the information and measurements as three or four appear on screen at a time, compared to just one at a time with the DCA55. In some cases, the measurements are also more precise. For example, bipolar transistor V_{BE} is read out with three decimal places rather than two.

The DCA75 can recognise and analyse zener diodes up to 12V, while the DCA55 did not (or detected them as regular diodes). It can also now handle IGBTs, including both enhancement and the rarer depletion mode types. It will recognise voltage regulators with outputs up to 8V and display the drop-out voltage and quiescent current. That's handy since if you have an unknown TO-92 package 'transistor' the DCA75 might tell you it is a regulator!

As with the DCA55, this unit does more than just look at the basic component type connected. For bipolar transistors, it will also detect internal collector-emitter (freewheeling) diodes. For Darlingtons, it will detect if there are internal base-emitter biasing resistors. It will also detect diode networks (common anode, common cathode, series) which are often found in SMD packages such as SOT-23 and SC-70.

In addition to standard LEDs, it can sense 'bicolour' (inverse parallel) and 'tricolour' (common anode/cathode) types. And since it lights the LEDs up briefly, you can check the colour and brightness.

The supplied manual is good. Not only does it explain in detail each type of test, what the limitations are and so on but it also shows the equivalent test circuit used for analysing each device. There is also a complete list of specifications for accuracy and measurement range in each test mode. The section on the PC software is very short but the software is not difficult to use.

PC software

If you're going to take advantage of the new USB connectivity, you will need a computer running Windows XP or later. A USB flash drive is supplied but (like a lot of supplied equipment software) it is likely to be out of date; you can download the latest version from the PEAK Instruments website at http://peakelec.co.uk/acatalog/dca75_support.html

They also supply a micro-USB cable.

As stated earlier, the range of analysis provided by this unit is somewhat limited due to its relatively low voltage and current delivery capabilities. It's fine for testing low-voltage semiconductors typically found in digital circuits but not quite as useful for high-voltage or high-current devices such as those found in audio amplifiers, TVs, power supplies etc.

For those low-voltage devices though, you can perform some quite useful tests, as shown in the accompanying screen grabs. For a start, you can do all the same tests as you can with the stand-alone unit but the results are displayed in a friendly format with all the results visible at once (see Fig.1).

For each type of component, you then get a choice of several different graphs to plot and you can customise the range of test parameters (bottom of Fig.2). For most tests, there are two ranges of parameters that it steps through and this results in a series of curves being plotted.

In Fig.2, we are plotting collector-emitter voltage (V_{CE}) against collector and base current for a BC557. This demonstrates the "Early effect"; in an 'ideal' transistor, once saturated, the lines would be perfectly horizontal. Fig.3 shows a plot of H_{FE} (beta, or gain) versus collector current for a range of collector/emitter voltages for the same device.

Naturally, the tests available for Mosfets are somewhat different than for bipolar transistors. Fig.4 shows a plot of channel (drain-source) current against gate voltage for a range of drain/source voltages. This is a useful plot for any Mosfet as it allows you to see the gate threshold voltage. For example, this would be useful if there is ever a need to match pairs of devices.

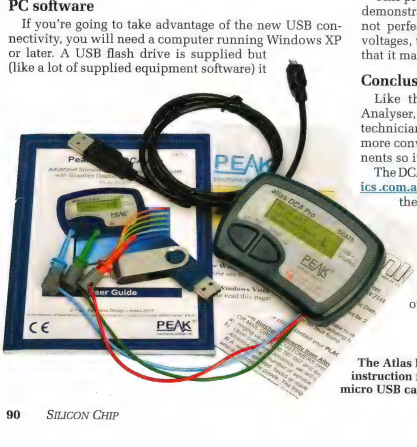
This plot gives the expected square-law curves and also demonstrates the Mosfet's on-resistance as the curves do not perfectly overlap. Note that at higher drain-source voltages, the unit can't test to as high a drain current; not that it matters terribly in this case.

Conclusion

Like the older DCA55 Semiconductor Component Analyser, this is a handy tool for just about any electronic technician to have. But the new DCA75 model is definitely more convenient to use and tests a larger range of components so it's the more desirable one to own.

The DCA55 is still available from Altronics (www.altronics.com.au), for $110 including GST (Cat No Q2100), while the DCA75 is $259 including GST (Cat No Q2115).

The USB analysis mode is definitely a useful feature and could justify the higher cost, especially if you are going to use it on a regular basis. If you can't afford the DCA75 though, the DCA55 is still quite useful. Any good electronic technician should have one or other of these devices in their toolbox. SC



The Atlas DCA75 Pro comes with a comprehensive instruction manual, a USB stick with PC software and a micro USB cable. Altronics provide the local warranty.

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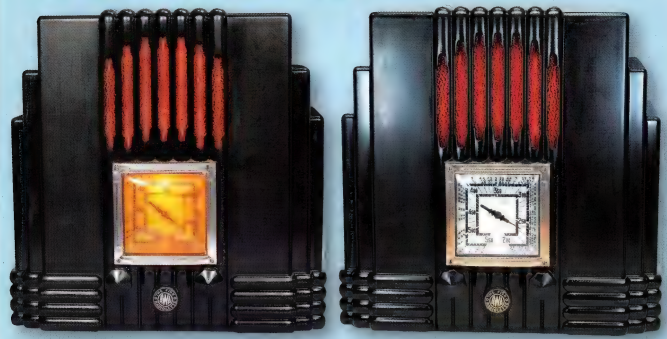
Vintage Radio

By Associate Professor Graham Parslow

The AWA Empire State: the definitive icon of the Bakelite radio



The view at left shows the R28 radio with its original aged (and yellowed) celluloid window and dial face while at right is the restored unit with reproduction dial parts.

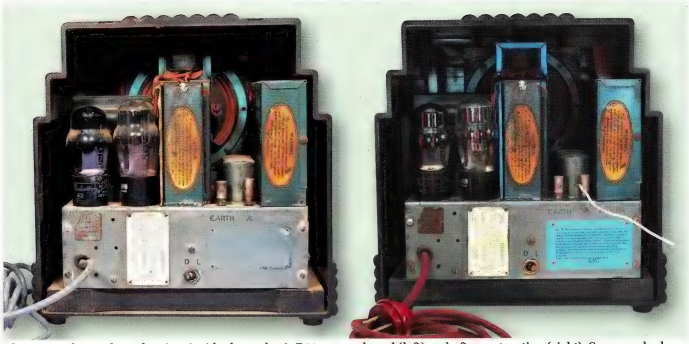
The beauty of the AWA R28 radio has grown along with the nostalgia for the period now called "Art Deco". AWA Empire State radios epitomise art from the "machine age" and have become the must-have radios for collectors in Australia (and beyond). Just as Penfold's Grange Hermitage has become Australia's iconic wine and is now expensive, the Empire State is now a definitive icon and is also expensive.

THE VINTAGE radios featured in SILICON CHIP are usually discussed in terms of the underlying technology of their RF (radio frequency) and audio sections. However, the Empire State's mystique owes little to its technology, although it was a state-of-the-art superhet radio for its time.

Instead, its mystique derives from its perception as a classic of design and in this context it's appropriate to diverge a bit from simply listing the technical details. What makes a classic? It is almost always the intent of a designer to unleash a classic on the world but it is the fickle nature of public taste that determines the outcome.

I can illustrate this through my ownership of a 1965 Ford Mustang fast-back that I bought back in 1975 when it was merely an old car. These days, I can hardly stop at a petrol station without someone coming up to say what a beautiful car it is and wanting to have a chat. It *is* a classic!

AWA produced a series of Bakelite Empire State radios between 1934 and



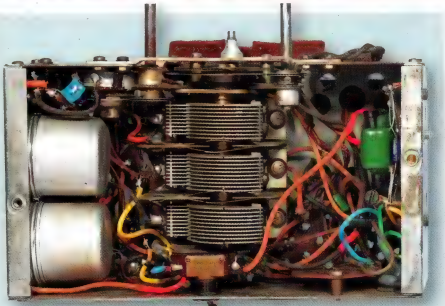
These two photos show the view inside the author's R28 as purchased (left) and after restoration (right). Someone had replaced the mains cord at some time in the past but this non-original item was replaced with a cloth-covered mains cord fitted with a Bakelite plug which is more in keeping with the era. A reproduction ARTS&P label (blue) was also fitted to the restored receiver. The chassis is best removed from the cabinet by unscrewing the four rubber feet at the bottom rather than undoing the two screws that attach it to the wooden base (doing the latter makes reassembly difficult).

1937 (Radiolettes R28, R29, R30, R31, R32 & R37 and Radiola R48). AWA were the biggest Australian manufacturer of radios in the 1930s and their most profitable and best-selling lines were console radios. These were large floor-standing units for the lounge room, which were marketed on the attractiveness of their timber cabinets.

By contrast, there was a stigma at the time about "plastic" items that were perceived as cheap and inferior. Plastic (from the Greek plastikos, meaning mouldable) became the descriptor for all man-made polymers, including Bakelite.

Is the Empire State a truly Australian design? There is an urban myth, found by a Google search, that the shape is modelled on the Art Deco profile of AWA's Sydney headquarters tower. This is easily refuted because the building was not erected until 1939. Borrowing from US radio designs, with inspired adaptation, is a more credible explanation.

The R28 radio was most likely styled after the Air King Model 66 designed by Harold Van Doren and John Gordon Rideout in New York, 1933. It is now a classic for US collectors. For Australia's most iconic radio, there is no accessible information about the decisions made by management and the composition of the design team that led to the Empire State radio.

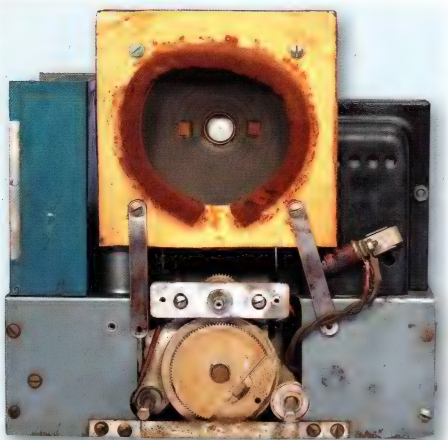


The component layout under the chassis is rather crowded due to the fact that the R28's cabinet has just 240mm of usable width. Even so, the cabinet was one of the largest moulded Bakelite cabinets at the time. A previous owner had replaced the capacitors and the mains cord. The new cloth-covered mains cord fitted by the author was correctly restrained using a cable clamp rather than using a knot (as shown here) which is now illegal.

Bakelite

Bakelite is a thermosetting plastic which is a condensation product of phenol and formaldehyde. In 1907, it was the world's first synthetic plastic and marked the introduction of the 'polymer age'. Pure Bakelite resin is a pleasant shade of amber.

Unfortunately, the pure product is



This view shows the front of the chassis without the dial. Note the geared drive mechanism for the dial pointer which rotates through almost a full 360°. The 5-inch (125mm) electrodynamic speaker still sounds good.

brittle and it was Leo Hendrick Baekeland (1863-1944) who empirically modified the properties by strengthening the phenolic polymer with fillers, initially with asbestos and in subsequent commercial applications with cellulose (sawdust) or starch from flour. Moulding Bakelite to useful shapes requires high temperature and pressure. A pressure of 350 tons was used for the moulds that made the Empire State cases.

A rare jade-coloured model features on the cover of this book titled "Radio Days: Australian Bakelite Radios".

The R28 radio featured here is the first of the series and was only released in black. An alternative polymer (formaldehyde-urea, trade name 'Radelec') with added colourants was subsequently used to create a remarkable range of finishes. You can see the colourful results by making a Google image search for "Empire State radio".

An even better way to see the colour variants is to acquire the impressive coffee-table book "Radio Days: Australian Bakelite Radios", by Peter Sheridan and Ritchie Singer. The promotion for this book from Angus and Robertson reads: "A unique and beautiful publication charting the history of the Bakelite radio in Australia. For the first time, a photographic history from the '30s, '40s, and '50s, highlighting art deco design in radio and the extraordinary range of colours. This title will be a must for anyone interested in Australian social history, design and nostalgia. This handsome production displays over 400 radios in colour on 230 pages."

If you are unable to locate a bookseller with stock, try emailing Peter Sheridan at peter@petersheridan.com You can also use Amazon to acquire Peter's latest book: "Deco Radio: The Most Beautiful Radios Ever Made".

Bakelite was cheap per unit in volume production but it required a high investment cost to set up moulds and presses. By contrast, the costs associated with set-up for modern thermo-mouldable plastics, such as PVC, are negligible relative to Bakelite and production rates are much higher.

It's no mystery why the production of Bakelite radio cabinets ended in the early 1950s.

Celluloid

The most plentiful natural polymer in the world is cellulose, the structural material of trees and other plants. Cellulose (as its nitrate derivative) was the basis for an early polymer that was transparent and mouldable, most notably as the base of photographic film.

The use of celluloid dates from 1870 but it's basically a natural product rather than a synthetic formulation. Unfortunately, cellulose nitrate undergoes slow oxidation and changes colour to yellow and becomes more brittle with age (similar to the way its parent polymer, cellulose, contributes to changing wood colour and properties with age). The dial window used for the Empire State radio is celluloid and the example featured here was appropriately aged.

The importance of originality can be argued vociferously but for this radio I purchased reproduction plastic versions of both the transparent window and the celluloid station-calibrated dial. The "as new" result is my preference in this case but the original celluloid dial parts have been put away for safe keeping.

ARTS&P

The Empire State is a superhet design and sets of this type were only just beginning to become widely available at the time of its release. The superhet design was desirable because of its ability to discriminate between stations with small frequency differences. This was becoming increasingly

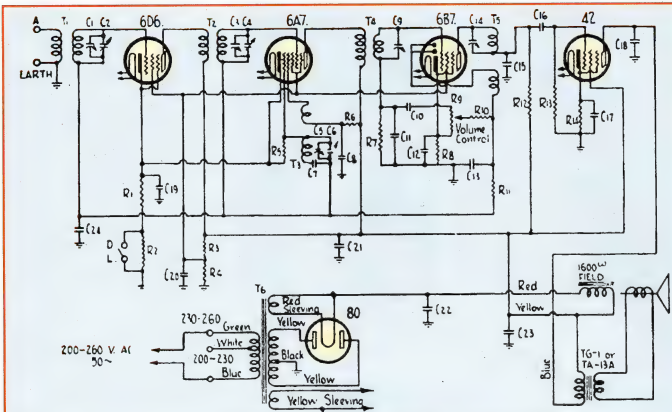


Fig.1: the circuit of the AWA R28. It has a fairly conventional RF amplifier (6D6) stage followed by a 6A7 converter and then a 6B7 IF amplifier/detector/AVC rectifier/audio amplifier. The latter then drives a type 42 pentode output valve, while a type 80 provides full-wave rectification of the transformer secondary to produce the HT voltage. The "D-L" switch across resistor R2 alters the gain of the 6D6 for distant and local reception and was necessary to avoid overload on strong signals.

important as more and more stations began crowding onto the airwaves during the 1930s.

The superhet design goes back to 1918, when it was invented by Edwin Armstrong as a means of obtaining better amplification of RF (radio frequency) signals. This was done by converting the received signal frequency to a lower frequency (the IF or intermediate frequency) that could then be better amplified by the inefficient valves of the time.

Ongoing arguments about who owned the patents and rights to royalties kept the superhet out of general commercial production in Australia until a compromise was eventually reached. This involved manufacturers paying a set royalty to a single agency that would distribute the money. AWA overcame these patent problems to make superhets in the 1920s but these did not perform to modern standards.

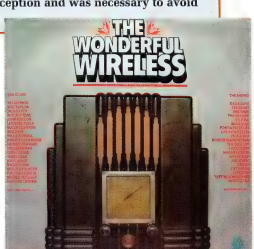
A label on the back of the Empire State R28 lists the various patents embodied in the radio and these date from 1919-1932. Also affixed to the back was an Australian Radio Technical Services and Patents (ARTS&P) label that certified that royalties had been paid.

Each label was uniquely identified by a serial number and the first year of issue was 1934, the year the R28 set featured here was made. Unfortunately, only some miniscule white residue of the original label remained when the radio was purchased. I now know that 1934 ARTS&P labels were white but the R28 was also sold during 1935 when the labels changed to blue.

The other R28s I initially looked at all had blue ARTS&P labels and this caused some confusion. After looking at those labels, I made a reproduction for this radio and unfortunately it is erroneously blue and carries a 'B' prefix. A future project to create a white ARTS&P with the correct 'A' prefix for 1934 is planned.

Circuit details

Fig.1 shows the circuit details of the Empire State R28. As shown, it's a 5-valve set with three tuned circuits.



The album cover of this double record set produced in 1982 by Telmak (Balmain, NSW) lists artists and recordings of the heyday of radio from the 1930s to the 1950s. The dial indicates that this is an R48 model but it is fitted with non-genuine knobs. The speaker grille fabric is also non-genuine.

The five valves are as follows: (1) a 6D6 (or type 78) RF amplifier, (2) a 6A7 mixer-oscillator producing an IF of 175kHz, (3) a 6B7 IF amplifier/

The R48 uses asbestos to line one side of a metal can holding the two HT filter electrolytics, to protect them from heat generated by the type 80 rectifier. This asbestos was painted with high-temperature blue paint to stabilise it (see text). The left photo shows the asbestos before painting, while the right photo shows the asbestos after painting (rectifier valve removed).

The 6D6 RF valve, the 6A7 converter valve and the 6B7 IF amplifier/detector/audio amplifier valve are all shielded by a divided metal screen at one end of the chassis (the later R29 model is easily recognised because it has separate shields around the individual valves). The two IF transformers are located under the chassis, immediately below the converter and IF valves. The warning label reads "This instrument has been designed for the use of Radiotrons. To ensure consistent good results and to safeguard against possible damage use only genuine Radiotrons of the correct type as replacements".

detector/AVC rectifier/audio amplifier, (4) a type 42 output pentode and (5) a type 80 HT rectifier.

The three tuned circuits are adjusted by a triple-gang tuning capacitor, the various sections being associated with the aerial coil, the inter-stage RF transformer and the local oscillator. Note that the 6B7 reflexes the output of the detector diode back to the grid so that the valve simultaneously amplifies both IF and audio signals.

The power supply uses a conventional transformer. Its secondary output is full-wave rectified by the type 80 and the resulting HT line is then filtered by C22, the loudspeaker field coil and C23. The filtered HT voltage is then fed to the plates of the valves.

Restoration

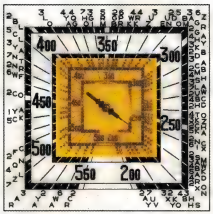
This unit was in quite good condition when received but there's one critical aspect to watch out for in this set. A priority in dealing with an R28 (and other old radios) is to assess the state of any asbestos, if present. Many radios of the 1930s and 1940s incorporated small asbestos sheets to provide heat shielding and these sheets were generally attached to structures adjacent to the hottest valves (rectifier and output pentode).

In the R48, the type 80 rectifier valve dissipates about 8W of the 48W total and asbestos lines the side of the can housing the two HT filter electrolytics. This asbestos was painted blue using high-temperature paint (eg, from Stove Bright or White Knight), to stabilise it against shedding airborne spicules.

It's essential to wear the correct protective equipment when working with asbestos. Miniscule amounts of asbestos can cause deadly long-term health problems if inhaled. Ordinary dust masks are not effective and protection requires a filter respirator fitted with a class P1 or P2 filter cartridge.

Any clothing must also be protected from contamination and you should not use compressed air to blow away dust if asbestos is present. Guidelines for dealing with asbestos are available at http://www.health.gov.au/

In this case, the R48's chassis was cleaned with turpentine to remove the dust and grime. Matching blue paint was then applied to some areas of corroded metal work. The grille fabric was thin with some small holes, so a dark brown backing fabric was added behind the original material. This en-



The yellow inset section here is the original R28 dial from 1934 but more stations had joined the airwaves by 1936 when the R29 was marketed. The outer section is the reproduction R29 dial installed on the R28 radio featured here.

Ernest Fisk was the General Manger of Amalgamated Wireless of Australasia at the time the R28 was made and was a familiar public figure in the 1930s. He made various royalty agreements with both Marconi UK and RCA America, the latter also giving him the rights to use the badge names "Radiola" and "Radiolette" (as used on the front of the AWA R28).

hanced its appearance while showing no evidence of the added fabric.

Unfortunately, heat from the dial-light (a 6.3V 2W globe) had resulted in a small burn mark on the celluloid dial-scale. This, along with yellowing of the dial-scale, led to the decision to replace it with a reproduction.

Finally, considerable effort went into carefully polishing the cabinet. The result can be seen in the accompanying photo.

The price of an icon

At the time of its release in 1934, the basic AWA Empire State Radiolette R28 was considered an "entry-level" set and sold for £15/15/– (ie, 15 pounds and 15 shillings). This was subsequently increased to £16/16/– (or 16 guineas as it was then quaintly called) for the R39 in 1936. A tradesman at that time earned about £4 a week, so even entry-level sets weren't cheap considering they cost around four weeks' wages.

These sets were advertised as the "second set in the home for the kitchen or sunporch." And in keeping with this theme, later models were promoted as having "a sparkling array of beautifully coloured cabinets which harmonise perfectly with modern interiors".

The basic black and brown units have survived in reasonable numbers but that does not make them cheap today. The unit featured here was purchased on eBay for $1600 in January 2010. The highest price known to be paid at auction is $16,800 in March 2010 for a jade-green example. A jade-green example has also changed hands privately for around $20,000.

These high values have sometimes led to flagrant misrepresentations of kindred radios (and reproductions) as Empire State models. As ever, when purchasing such sets, it is caveat emptor; let the buyer beware. The luckiest acquisition I know of is by a fellow collector who found one at his local tip.

Despite the high prices paid for some models, they're far from being the most valuable vintage radios on the world stage. That honour goes to a rare art-deco Sparton Nocturne which fetched US$120,000 in Los Angeles, USA.

So where do you display an Empire State radio? Easy – taking a cue from the movie "The Castle", it went straight to the pool room.

This view shows the author's fully-restored 1934 AWA Radiolette R28 with its reproduction R29 dial. Along with restoring the electronics, considerable effort was also put into restoring the cabinet, so that it now looks almost like new.

Acknowledgement

Peter Sheridan and several members of the Historical Radio Society of Australia (HTSA) provided helpful information during the preparation of this article. SC

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Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Using the Majestic as a subwoofer

I have read with great interest about the Majestic Loudspeaker System project in the June 2014 issue. My question is, can it be an awesome stand-alone subwoofer?

Obviously the main changes would be to delete the horn tweeter, crossover network and associated tweet cut-out in the front baffle. But is that all? Would the dimensions of the box have to change to accommodate the loss of tweeter changing the internal volume? Can the dimensions of the box change, provided the internal volume remains the same? Would this affect the size of the two ports? (T. H., Calwell, ACT).

● Your approach is correct. Just leave out the tweeter, crossover network and the tweeter cut-out in the baffle. The volume displaced by the back of the tweeter is quite small so it should have little effect on the overall response. No dimensions need to be changed.

SoftStarter for circular saw

I have bought a Ryobi table saw rated at 1500 watts. It starts with a solid 'thwack' which I find objectionable and disconcerting. I have checked a similar unit and it makes the same noise when started. SILICON CHIP described a slow start unit in July 2012. Would this be suitable to use with the saw? (B. T., via email).

● Yes, it should be suitable. That unit has a rating of 10A (2300VA) so should handle a 1500W saw.

Keep in mind though that if you're starting the saw frequently (say once a minute or more often), then the effectiveness could diminish with subsequent starts as the thermistors may not have time to fully cool down. Even then, it should still provide some reduction in start-up kick.

AC voltage regulator wanted

I am trying to build a voltage regulator so I can reduce the voltage from 250VAC to 24VAC. If you happen to have a kit for this it would be very nice. I have tried using a couple of formulas from the internet but to no avail since the values do not compute and the results are dangerous in some cases. (C. H., via email).

● There aren't many true AC voltage regulators available. One option is to use a motor-driven Variac but they are expensive and only react relatively slowly – they're intended to cancel out the effect of mains voltage variations.

Are you sure you need regulated AC and can't just use a regular transformer? How important is it that the AC is a sinewave?

If you must have a precisely regulated AC voltage then the obvious solution is to use an audio amplifier, however depending on what type of load you need to drive (capacitive, etc) you may run into stability issues.

A single-channel audio amplifier capable of delivering 100W into eight ohms should be able to deliver 24VAC at around 3A. It will be quite inefficient though. Ideally, use one rated for 4-ohm loads so that it has sufficient current delivery margin. Feed a 50Hz sinewave from an oscillator into the amplifier input then adjust the volume control for 24VAC between the speaker terminals. You may need to re-adjust after connecting the load. Ideally you should then check that there is no sign of oscillation with an oscilloscope.

Speedo Corrector misbehaves at 90km/h

I am writing in regards to the Speedo Corrector Mk2 (SILICON CHIP, December 2006). I have one installed in a VS Commodore and it is receiving and transmitting an AC signal.

Piezo Tweeter Substitution In Majestic Loudspeakers

I am probably going out on a limb here but I have a couple of the older CTS piezo 400W horns which I would like to use instead of the Celestion tweeters in the Majestic Loudspeaker System (SILICON CHIP, June 2014). These sound fine to my (cloth) ears with a 200W/channel amplifier and German 12-inch woofers. It will be using an active crossover at about 1.8kHz, 24dB/octave. I hope the 15-inch Etone woofer holds up that high; it might need some active shelf EQ.

I will also need to boost the piezo tweeters by 3-4dB but using SILICON CHIP Ultra-LD Mk.3 Amplifier modules for this should be OK. Please feel free to point out the deficiencies in this approach! (J. E., by email).

● Aargh, piezo horns really have no place in a high-fidelity system! So good luck with the experimentation. Keep in mind that we (Allan Linton-Smith & SILICON CHIP) have spent considerable time with the Majestic Speaker design to get it just right in terms of treble/bass balance, sufficient treble dispersion, good bass response, etc.

If you change the tweeters and crossover network you will have to do a lot of the tweaking all over again to get the balance right and that will be virtually impossible unless you have calibrated microphones and all the gear to match.

Sometimes things which seem like they'll work well on paper don't necessarily result in speakers that sound good. At the very least, we suspect you will want to try different crossover frequencies and ideally should have a way of measuring the change in frequency response as you do – see the article on measuring loudspeaker systems in the December 2011 issue of SILICON CHIP.

Questions On The 12-Digit Frequency Counter

I am in the process of building the 12-Digit Frequency Counter from the December 2012 and January 2013 issues. It is somewhat disappointing that there was no kit available but I understand you have no control over these matters. Small quantities of some of these parts are hard to obtain and some are now discontinued stock.

I have a few questions regarding this project please. First, is the long gating time add-on board, published in July 2014 available yet? Second, in respect to obtaining the best frequency accuracy, what would your recommendations be please? I have both a Trimble Thunderbolt GPS and a Rubidium standard with the SILICON CHIP interface to provide the 1Hz signal. Is one better than the other?

Also, in the circuit description, it says that the 8MHz crystal associated with the microprocessor handles some of the counting process, so if this crystal drifts, is the accuracy also going to suffer? Would it benefit from having a crystal heater fitted?

My main motivation for building this counter, is to measure and adjust my 10MHz reference oscillators, used for microwave transverters, up to 78GHz. I do have a HP microwave counter but it is temperamental and unreliable.

A 12GHz prescaler, added to this counter, would give me the same functionality, with possibly better accuracy and resolution. I currently use a Rubidium standard as the reference oscillator on my testbench, to drive signal generators etc, but I want a second 'reference' as a sanity check.

Any advice on optimising the accuracy would be appreciated. (P. W., via email).

- The PCB for the long gating circuit for the 12-Digit Counter can be orderd via this link: **www.siliconchip.com.au/Shop/?article=7927**

We are not familiar with the Trimble Thunderbolt GPS, so we cannot advise whether it would provide a more stable 1Hz output compared with your Rubidium standard. You don't say whether the Rubidium unit is GPS-disciplined or not but if it is, the stability and short-term accuracy should be about 'as good as you'd want'.

With regard to your question regarding whether or not the accuracy of the 12-digit counter might be compromised by the use of a non temperature-compensated or non-ovenised 8MHz crystal for the micro, the answer is "no". The gate timing for the counter is solely determined by the timebase, so if you are using the external timebase option with GPS-derived 1Hz pulses, these will determine the counter's accuracy – at least for frequency measurements.

The micro's 8MHz clock is only used to provide the 1MHz clock for period measurements. Although the 'later decades' part of the frequency counting (ie, after the first four decades) is certainly handled by counters inside the micro, these are hardware counters rather than software counters, so they're not affected by any drift in the 8MHz clock.

It works fine except for when speeds reach about 90km/h and above. Above 90km/h the speedo jumps around, up to 100km/h and and back down to 95km/h (ie, about 5-10 km/h either side of actual speed). This happens all the time above 90km/h but it is perfect below.

It appears there is noise on the signal but without the Speedo Corrector the speedo just reads high right up to 200km/h without jumping! When the speedo jumps around it also appears to react when the accelerator is pressed. If I take my foot off the accelerator above 100km/h, the speedo drops to 95km/h; put my foot back on and it jumps back up but actual speeds, checked with a GPS, are steady!

I have investigated noise on the power supply and have eliminated this with a noise suppressor and this made no difference to the jumping signal. I have also double checked the grounds throughout car! Do you any idea what my problem might be?

I have now installed two different Jaycar Speedo Corrector kits and both act the same! Secondly, I think the problem might be something like debounce or filtering of the incoming or, most likely, the out-going signal? Is there a way I can filter the output more? Increase a capacitor or resistor? Can the micro be reprogrammed to filter or increase the de-bounce? (S. E., via email).

- The problem is most likely insufficient filtering of the input signal. Try increasing the 10nF capacitor across ZD2. This capacitor is located just below transistor Q1 on the PCB. Maybe a 100nF capacitor will fix it.

Another problem could be electromagnetic interference causing the microcontroller to misbehave. Try relocating the Speedo Corrector to a different position in the vehicle, preferably away from the ignition leads. Finally, try replacing or increasing the 100nF capacitor that decouples the supply to IC1. This is located adjacent to pins 1 and 18 of IC1.

Seismograph set-up problems

I have constructed the Seismograph (SILICON CHIP, September 2005) and have followed the steps outlined in the article. However, when the AmaSeis software is opened it cannot receive data from the chip. A message comes up on the screen that it cannot communicate with the device.

The COM port is set to the same as for the PICAXE. The baud rate is 4800 and AS1 is set. I am using the Revolution Education AXE027 USB download cable. I have checked all parts on the PCB and the voltages on the chips.

The second problem is when power is applied to the circuit board the piezo transducer goes into a continuous chatter mode. I hope you are able to offer a some suggestion which may help to solve these two problems. (B. S., Auckland, NZ).

- Did you close the PICAXE Programming Editor to free the COM port before launching AmaSeis? You can use a basic terminal program (which is built into the PICAXE programming editor) to connect to that COM port with a baud rate of 4800 and you should be able to see data from the unit as shown in Fig.6 in the article.

Check that the supply voltage for IC2 is a stable 5V or very close to it.

24V Version Of Ultrasonic Anti-Fouling Unit

I put together the Ultrasonic Anti-fouling Unit For Boats (SILICON CHIP, September & November 2010) and it worked well for some time. However, at some stage, my 12V switchmode reducer seemed to reach up to 17.7V and the result was the destruction of the ICs and the Mosfets. Is it possible to advise on modifications for operation on a 24V system?

I assume that this would involve replacing the resistors in series with diode D3, the 20kΩ and 10kΩ divider resistors, plus the resistor in series with the run LED. Also, the transformer would need to have increased turns on the primary. I would prefer to run the unit directly off the boat's nominal 24V system. (R. L., Christchurch, NZ).

● To run the system from 24V you would need 16 turns on the primary instead of the eight used for use with a 12V supply. You may find there is little room for the extra windings and so 1.25mm diameter enamelled copper wire will provide a space saving. You must insulate between primary and secondary windings with insulation tape.

If you built the unit from a Jaycar kit you may find that the cores are difficult to separate as they have been glued in the pre-wound transformer. You could wind a new transformer instead (element14 sell ETD29 transformers).

The 2200µF 25V low-ESR capacitor would need to be rated at 35V or more. Also, place a 10V 1W zener diode in series with diode D3, with D3's anode to the anode of the zener diode. This will reduce the input voltage to IC1. The 100µF capacitor at pin 1 of IC1 needs to be rated at 25V (or more if the zener is not used). Reduce the fuse rating to 1.5A.

The 20kΩ and 10kΩ resistors at pin 5 of IC2 for battery voltage monitoring should be changed to 18kΩ and 3.6kΩ, respectively. This will divide the 24V battery voltage by six instead of a factor of three. LED1's series resistor can be 10kΩ 0.25W.

We assume that programming the chip was successful and that you have adjusted VR1 and VR2 as per page 34 in the article.

Piezo chatter is probably normal before the final adjustment is complete (as per the instructions on page 36) since the earlier steps say to set the voltage at pin 3 of IC2 to around 4V. However, we suspect that it should actually be closer to 2.5V during normal operation. You could try adjusting VR2 to get 2.5V at pin 3 and see if that quietens the piezo.

If so, then the unit is probably working and it's just a serial communications problem, possibly because the PICAXE programming editor (or something else) has the COM port open.

Preamplifier needs multiple inputs

I wonder if I might ask your opinion about the 10-Channel Remote Control Receiver featured in the June 2013 issue. I am in the process of building a new stereo system and one of the problems I have encountered is finding a design for a preamplifier with sufficient inputs for all the various items I want to run, eg, CD, TV, digital radio, MP3 etc. I need a minimum of five inputs and I would really like them to be controllable remotely.

Looking at your design, I believe that I could use it to operate readily-available 4PDT relays mounted on a PCB which would allow me to switch both left and right signals and both grounds on a stereo input. I appreciate that the receiver would have to be set to toggle operation and I would therefore have to turn off each unwanted input but the consequences of two inputs/relays on at the same time would only be a brief mixing of program material which is a minor inconvenience.

Since I am likely to use the Altronics A1012 remote to operate a motorised volume control it should be possible to use the same remote for the input switching. Can you see any obvious problems with this approach? (B. D., via email).

● The 10-Channel Remote Control can be made to work as you describe. The hand-held remote would be suitable for both motorised volume control and input selection.

With relays there could be some inter-channel crosstalk for both input signal and left and right channels. Ensure there is sufficient shielding of the signals and, if using a PCB, that ground tracks are run between adjacent signal tracks.

Tamper alarm for an electric fence

Has SILICON CHIP published an Electric Fence with a tamper alarm? The idea is that if the wire is cut, it will sound an alarm. (D. H., Taipei, Taiwan).

● We have published a few electric fence circuits. The main ones were in July 1995 and April & May 1999. None of these had an alarm to indicate if the fence is cut but it wouldn't be hard to arrange. You do need access to the far end of the fence from the controller, or alternatively connect an insulated wire there and run it back to where the controller is.

First, connect a high-voltage rectifier diode and a low-value, high-voltage filter capacitor to this wire to rectify the output of the electric fence controller, without loading it unduly. That done, connect a high-value resistive divider (eg, 10 x MΩ 1W and 10kΩ) across the capacitor, such that the divider develops a few volts across the bottom resistor (ie, the low-value one connected to earth) when the fence is working properly.

You can then use that signal to reset a timer, with the timer set to sound an alarm if it is not reset in say 2-3 electric fence pulses. Should the fence be cut, the voltage to the far end will stop and the timer will expire and sound the alarm.

Speed query on Ethernet over power

I read with interest your article in the June 2014 regarding Ethernet via 230VAC mains. As a somewhat non-technical person could you please clear up a question for me. The picture of the Edimax, on page 77, shows 500Mbps (on the device itself) yet the caption under the picture states 100Mbps.

Also on page 78 – middle column, second last paragraph – it again states that the adaptors have 100Mbps ports. I have my modem/router/WiFi device in the lounge room (adjacent to the phone line wall socket) while my home office is in the back of the

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SoftStarter For A Ducted Vacuum System

Recently, I purchased and constructed the SoftStarter kit from Altronics, based on the article in the April 2012 edition. I installed the kit to provide a soft start to a 230VAC mains-powered 1500W series-wound AC brush motor in a domestic ducted-vacuum motor. The circuit worked as expected for about six weeks after which time the thermistor failed, disintegrating into several small pieces.

It was not being switched on and off rapidly. It was mounted in a 200 x 140mm sealed ABS box, which also contains a 24VAC mains control relay for the vacuum motor on/off function and a 7A mains circuit breaker. The 24VAC supply for the control on/off relay is external to the box. It was used four or five times per week for about six weeks until failure.

The remaining bit (about 40%) of the thermistor now has a low temperature resistance of about 40Ω, so there is still some limited soft start functionality but not as designed or for safe use.

The other components of the circuit are undamaged. The relay coil and contacts test OK. The ducted-vacuum motor still works normally without the Soft Starter and draws up to 6A on full load as originally purchased. The initial start-up current is of course much higher hence the benefit of using a Soft Starter.

The vacuum motor has a light load at start-up but a moving-iron ammeter flicks up to at least 15A, so perhaps depending on the instantaneous time of switch-on (eg, at the peak of the 50Hz waveform) it was eventually overloaded, especially if it had already begun to fail.

The critical part of the kit is the Ametherm SL32 10015 NTC thermistor and I am considering using two in series as this would reduce the energy (power dissipation) in each thermistor to around 25%. Altronics have offered replacement thermistors. Is my use of the SoftStarter within your design criteria or have I just been unlucky with a faulty thermistor? If not, can you please suggest a solution? (M. R., via email).

● The NTC thermistor is rated for 15A continuous current. While a moving-iron ammeter probably doesn't capture the full extent of the initial current spike, from the sounds of it that should have been within its capability. We suspect a faulty part.

Your idea of putting two in series is worthwhile. That's what we did in the SoftStarter for Power Tools (Silicon Chip, July 2012) and it seemed to work well. We haven't had any complaints of thermistor failure with that project even though people will be using it with power tools with similar ratings to your vacuum cleaner.

house and is very unreliable for the WiFi to connect – I suspect because of distance.

I toyed with the idea of running a long Ethernet cable between the two locations but it would be a hell of a job to accomplish. Do you feel that these adaptors would solve my problem? I have a power point within a metre of where I have my laptop on my office desk. (K. J., via email).

● The speed ratings are a bit confusing but in essence, each port is only capable of 100Mbps. You can be pretty sure that the mains Ethernet approach will work. However, if you are not sure, there is probably nothing to stop you from trying the system out, eg, buy it and try it. If it doesn't work, take it back for a refund.

Programmable Ignition System for a VW Kombi

I am building a Programmable Ignition System (Silicon Chip, March, April & May 2007) and I wanted to ask a couple of questions. What is the output voltage level of the trigger signal that goes to the coil driver? It looks as if it would be 5V.

This is because I want to adapt the set-up to coil-per-cylinder sequential charging and firing (only the cylinder in use gets a spark and this helps cooling and efficiency, etc). This would be easy to do with AND gates plus a 4017 or latch type indicator to hold which cylinder is currently selected by the distributor. I noticed that the driver unit has provision for 5V (also logic level of course) drive signals. Perhaps there are other ways to do this but it seemed quite efficient.

I am searching Jaycar for the Sensym module. Is this where it is to be found? The vehicle is a VW Kombi 1973 air-

continued next page

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cooled 4-cylinder; a year before they went to fuel injection and sensors. The coils are Pertronix flame-thrower (2 x 45kV, epoxy core, 0.6Ω.)

There are several points in its original vacuum advance system that could be used for the Sensym sensor. One is from the fuel manifold but I assume contamination would not be good for the sensor.

- The open-circuit output voltage from the Programmable Ignition System is 0-5V. It may be difficult to arrange a system whereby the unit's output was directed to power separate coils, depending on the distributor position. Each coil driver would need to be connected immediately after the firing of the previous coil in order to maximise the dwell period.

The Programmable Ignition System does not have facility to provide a dwell period that is greater than the period between each trigger. In addition, this period is reduced by the firing period minimum of 1ms. You will not gain any advantage from using separate coils unless you have each coil driver start to charge its coil immediately after its own firing. This extra dwell will cause heating in the coil once it is charged. A ballast

continued page 104

Preamplifier For A Yamaha Electric Piano

I own a Yamaha piano (as distinct from a keyboard). The piano doesn't have enough output amplitude from 'Aux Out' to drive an amplifier, hence the need for a stereo preamp such as that described in April 1994.

In the kit, three alternatives are offered namely: magnetic cartridge, tape/cassette deck and microphone. I'm assuming that the RIAA curve would not be relevant and neither would the microphone option. I am intending to wire in the tape or cassette option.

Am I correct or can you suggest another option for low output pianos? (D. V., via email).

- None of the suggested options in the article would be suitable. The RIAA and Tape options have frequency tailoring and high gain while the microphone option has too much gain. Your Auxiliary output should have 100mV or more and typically 250mV, so a gain of four would probably be the maximum you need.

We suggest the same arrangement as the microphone option with R4 at 390Ω and R1 a wire link. The R2 value would only need to be 1kΩ for a gain of 3.56. If you need more gain, use a 2.2kΩ or 4.7kΩ resistor; for less gain, use an 820Ω resistor. Capacitor C2 can be 1nF.

resistor may be required to limit the maximum current in each coil.

The Sensym ASDX015A24R is hard to get. We recommend that you use an automotive MAP sensor. You can obtain new MAP sensors from: www.cyberspaceautoparts.com.au/contents/en-uk/d3721_Holden_Map_Sensors.html or from similar suppliers.

A secondhand MAP sensor can be obtained from a wreckers yard. We used a standard V6 MAP sensor in our prototype.

500W speed control for a 240V DC brush motor

I have a 230-240V DC 500W brush motor that has been removed from a treadmill and I need to be able to vary its speed. Would the new 230VAC Speed Controller For Universal Motors (SILICON CHIP, February & March 2014) work on this motor? (A. C., via email).

- Yes, this motor speed controller works with 240V DC motors. However, we suspect that your treadmill motor may be a standard universal AC motor. This is a series-wound brush/commutator motor which will run equally well on AC or DC.

Extra slaves for Micromite

Can you have more than one slave connected to a Master Micromite via the I^2C connection, as in Fig.8 on page 73 of the June 2014 issue. If so, how?

Also, have you considered modifying the 30A DC Relay project (November 2006) to have four or eight DPDT relays on one circuit board? The outputs could use header pins and/or screw terminals. A relay rating of 1A would be OK. I think this would be a useful to connect to a Micromite. (J. S., via email).

- Yes, you can attach multiple slaves to the one master. The only limitation is the number of I^2C addresses that are available (112 devices).

We do not have plans to modify the November 2006 project but yours is a good idea for the future. The board could also have inputs as well as relay outputs and could be controlled over I^2C. We will have a look at it to see if it's feasible.

Ultrasonic cleaner may be wired incorrectly

I have purchased and assembled your Ultrasonic Cleaner (SILICON CHIP, August 2010) and have a few issues you might be able to help me with.

After assembly, I did the first electrical check as per your instructions, removing fuse F1 and IC1 from circuit. The regulator voltage was within parameters of 4.85V and 5.15V DC. The power light comes on but the unit won't activate when set to timer or start and the run LED won't light.

I have included some photos to assist. Your thoughts on solving this problem would be appreciated. (B. F., via email).

- From the photos you supplied it seems that only two wires are connected on the PCB for the timer potentiometer. Depending on how this is wired to the potentiometer it will have an effect on the timer operation. It may be that the timer duration is so short that it finishes almost immediately after the Start button is pressed.

Check that pin 4 of IC1 is at 5V normally and then is at 0V while the Start switch is pressed. Check also that all the IC pins are correctly inserted into the IC socket and not bent under the socket. SC

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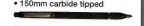

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